SCHOOL SCIENCE AND MATHEMATICS

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A HALF CENTURY OF TEACHING SCIENCE AND MATHEMATICS

"A Half Century of Teaching Science and Mathematics" is being published by the Central Association of Science and Mathematics Teachers to commemorate its fiftieth anniversary.

On June 7, 1902, a group of teachers of Physics in the central states met in Chicago and created an organization which they called the Central Association of Physics Teachers. The association held a second meeting during the Thanksgiving recess of that year. At this meeting a petition was presented from the Mathematics Section of the Educational Conference of Academies and High Schools requesting that they enlarge the organization to include mathematics teachers. During April of 1903, the larger organization was formed and was entitled the Central Association of Science and Mathematics Teachers. This was the last spring meeting of the group. All subsequent meetings have been held during the Thanksgiving recess. The meeting in 1950 will be the fiftieth convention.

Programs at the early meetings of the organization listed outstanding speakers and the group has continued to sponsor programs of an informative and inspirational rather than purely pedagogical nature. Members attending the conventions and reading the official publication, SCHOOL SCIENCE AND MATHEMATICS, have had the opportunity to keep in touch with the latest scientific and mathematical developments.

Now the organization is providing an additional service for its members and the general public by the publication of its anniversary book, "A Half Century of Teaching Science and Mathematics." As the title suggests the book reviews the progress in these fields during the past fifty years.

Prepublication orders are being received now. The price of the

book on these orders will be $2.50. After September 1, 1950, the price will be $3.00 a copy. Mail orders to Mr. Ray C. Soliday, Box 408, Oak Park, Illinois.

MARIE S. WILCOX

Ruth Weaver Mikesell

Ruth Weaver Mikesell passed away October 16, 1949 at the Chicago Memorial Hospital at the age of forty-three.

She was an honor graduate of the Scottdale, Pennsylvania, high school; received the B.S. degree from California Teachers College, California, Pennsylvania; and her M.A. in English and Geography from the University of Pittsburgh. Much of her training as a specialist in Geography was received in the graduate schools of the University of Chicago and of Northwestern University.

After a few years of teaching in western Pennsylvania, she became critic teacher for California Teachers College. From this position she went to Avalon-Pittsburgh Jr.-Sr. high school as teacher of Geography. After her marriage to Jerome B. Mikesell, she made her home in Chicago. She taught in the Oak Park and River Forest schools, then at Pestalozzi Teachers College in Chicago. In 1939 she joined the faculty of De Paul University as Assistant Director of the School of Education. At the time of her retirement, on leave of absence due to illness, she was Professor of Geography at De Paul.

During World War II she was the only woman teaching under the Army Specialized Training Corps Program at De Paul. She offered courses in Human, Economic, and Military (geopolitics) Geography.

Mrs. Mikesell took an early interest in the problems of teaching—particularly in the fields of the sciences and geography. She was not only an inspiring and outstanding teacher, but also an authority in her field. She was the author of "A Course of Study for Elementary Science" and "Objective Tests," published by Allyn and Bacon; a series of Travel Units on "Airplane," "Train," "Ships," etc. for use of teachers in junior high schools, published by Keystone View Company; and just before her death she completed Book I in a Science Series, "Voyages in Science," to be published by Loyola University Press, Chicago.

She was an active member of Pi Lambda Theta, American Association for the Advancement of Science, American Association of University Professors, Childhood Education Association, National Council of Geography Teachers, National Education Association, and Central Association of Science and Mathematics Teachers. She read many papers before these societies and, in addition, was a

speaker before teachers institutes and other educational meetings in the middle west. Her enthusiasm and charm and her practical understanding of the problems of teaching made these meetings stand out in the memories of those participating.

For her, teaching was a passion, a thrilling adventure. She was one of those teachers who truly love people and who carry their contacts beyond the classroom. Hundreds of letters from boys in service over seas as well as her large correspondence with former students in various walks of life are evidence of the respect in which she was held.

We in Central Association have lost an enthusiastic and treasured worker. She was one of the organizers of our Elementary Science Section, and an influential worker in our Geography Section. She served a term on the Board of Directors.

During the last two years of her life, knowing she was stricken with an incurable disease, she continued to face the world with her usual good cheer, gracious charm, patience, and fortitude. She leaves to her many friends and to her family a heritage of high courage and great valor.

KATHARINE ISENBARGER

THE QUIZ SECTION

JULIUS SUMNER MILLER
Dillard University, New Orleans 19, La.

1. A mass M is connected by a light string passing over a small fixed pulley to another light pulley over which passes a second light string connecting two masses m_1 and m_2. (a) Discuss the motion; find the accelerations and the tensions. (b) Find the condition for M to remain at rest. (c) Examine the case where $M=m_1+m_2$.

2. A particle of mass m hangs on a string of length L from a fixed point O. Let the mass be projected horizontally from its lowermost position. Discuss the motion.

3. A particle supported by a string which is taut and horizontal is released and when the string passes through the vertical it catches a peg at a distance d below the point of support. If the particle is to make complete revolutions about this peg find d.

4. A number of identical coins lie along a line on a smooth horizontal table separated by a distance equal to their diameters. The foremost coin is drawn aside and projected upon the next in line. Discuss the ensuing motion.

Hearing aid, for use in auditoriums by persons with normal hearing, is a complete tubular unit, vest pocket size, which contains microphone, batteries and complete transmitting system to lead magnified volume direct into the ear. In use, it is merely held to the head, with a conductor inserted in the outer ear.

EXPERIMENTS FOR THE SCIENCE CLASS

Julius Sumner Miller
Dillard University, New Orleans, La.

The following experiments will help to put life into your science class. They may be presented by the instructor or assigned to students for preparation and later presentation to the class.

A. A Simple Device for Showing Centrifugal Force

Fire-polish the ends of a glass tube about 10 or 15 cm. long and of 2 or 3 mm. bore. Through the tube pass a stout string or fish line a meter or so long. To one end of the string attach a 20 gram mass, to the other end a 200 gram mass. (Hooked weights are good.)

(1) Hold the tube in a horizontal position and demonstrate that the 20 gram mass (weight 20 g dynes) cannot, obviously, support the 200 gram mass (weight 200 g dynes).

(2) Hold the tube in one hand in a vertical position and impart a spinning motion, in a horizontal plane, to the 20 gram mass. It will now be observed that the centrifugal force (mv^2/r) on the 20 gram mass is sufficient to balance the mg of the 200 gram mass. If a knot is put in the string measuring off some convenient radius of action for the 20 gram mass, a count may be made by an observer with a stop-watch, whereupon mv^2/r may be computed. Since $v=\omega r$, and $\omega=2\pi f$, mv^2/r becomes $m\omega^2 r$, which goes to $4\pi^2 f^2\ mr$. This should have what magnitude?

B. A "Magnetic" Gun

Through an 8″ piece of round wood stock (roughly the size of a broom handle), drill about a $\frac{3}{8}$″ hole along the long axis, and smooth it out inside. (This is conveniently done with a rat-tail file or a hot iron rod.)

Wind about two layers of #10 or #12 enameled Cu wire on this spool. Allow several inches "play" at the free ends of the coil to which battery connections may be made.

Now find a rod of soft iron about 6″ long and about the size of a pencil that fits the hole *freely*. A 60 penny spike with the head sawed off does well, although softer iron is preferable.

Connect the coil through a key to a 6 volt storage battery. Hold the coil in a horizontal position and insert the iron core somewhat less than halfway. Close the key. The iron core is drawn into the coil. Open the key *before* the core is brought to rest inside the coil. The momentum of the core (aided by Lenz's Law) projects it some distance beyond the coil. With a little practice the "projectile" can be "shot" several feet.

APPLIED ENGINEERING MATHEMATICS*

JOHN PARMAKIAN
Engineer, Bureau of Reclamation, Denver, Colorado

On behalf of Mr. L. N. McClellan, Chief Engineer of the Bureau of Reclamation, I wish to thank the National Council of Teachers of Mathematics for its kind invitation to the Bureau to participate in this ninth summer meeting of the Council and for the opportunity to present this brief talk on applied engineering mathematics as it relates to the engineering activities of the Bureau of Reclamation.

As you may know, the Bureau is currently engaged in a program of construction of numerous Reclamation Projects throughout the western states. These projects include such major undertakings as Hoover Dam of the Boulder Canyon Project, Grand Coulee Dam and Pumping Plant of the Columbia Basin Project, the Colorado Big Thompson Project with its many diversion tunnels and power plants, and the Missouri Basin Project. Each project presents a wide variety of engineering structures. The unusual complexity and magnitude of the structures encountered have challenged the ingenuity and technical resourcefulness of many of our engineers. Moreover, the increasing costs of construction materials and labor have emphasized the necessity for reviewing with greater accuracy such engineering considerations as the actual behavior of our structures, allowable stresses, and safety factors. The analytical studies and mathematical investigations required in this closer scrutiny have made our engineers increasingly aware of the importance of applied engineering mathematics as an indispensable tool in our work.

Most Bureau engineers, through their background in basic mathematics and the allied sciences, are capable of solving the majority of the conventional design problems. However, where problems confronting the engineers are of an unprecedented nature, designs must be subjected to more rigorous analyses. The usual techniques and mathematical devices at a designing engineer's command may not be adequate to obtain solutions to the more complex problems presented. For this reason we are aware of the necessity for the inclusion of mathematical specialists familiar with the application of higher mathematics as an integral part of our engineering organization.

It may be asked at this point why all engineering under-graduates are not given additional instruction in higher mathematics to permit them to cope with more difficult problems in future engineering assignments. In this respect the present engineering curricula in most colleges and universities in this country are emphasizing the impor-

* A talk given before the National Council of Teachers of Mathematics, September 1, 1949.

tance of a well-rounded engineering education which will permit some graduates to assume positions as engineering administrators rather than as specialists. Hence, there has been less emphasis placed upon the requirement for additional mathematics. The prestige that American engineers have achieved throughout the world for their administrative ability and understanding of broad phases of construction and design is well recognized. In this regard, we can take pride in the Bureau's active participation in the current program for making the benefits of American scientific advancements and technical knowledge available for the improvement and growth of under-developed areas throughout the world. For example, at the present time Bureau engineers are assisting in Reclamation Programs in India and Southern Rhodesia. Other engineers have acted as consultants in Italy, China, Greece, Argentina, and Japan.

Despite the trend away from specialization in engineering education, many engineers are recognizing the necessity for specialization in their respective fields. As a result, it has become necessary for many graduate engineers to further their studies to obtain advanced degrees. In many instances this study was prompted by the need for higher mathematics. This is demonstrated in the Bureau's Branch of Design and Construction by the increased number of engineers who are obtaining master's degrees in engineering and mathematics.

Although nearly every engineer uses mathematics in one form or another specialization in the field of applied engineering mathematics is exemplified by the Mathematical Analysis Group in the Branch of Design and Construction. This group consists of about twenty men who regularly use advanced methods and techniques in engineering problems. Most of these men are engineers with master's degrees in Civil, Mechanical, or Electrical Engineering. In addition, nearly all of these engineers have completed courses in mathematics that include differential and integral calculus, differential equations, and advanced calculus. Many have also studied advanced courses in functions of a complex variable, theory of equations, operational calculus, matrix algebra, integral equations, and similar higher mathematical subjects.

The wide variety of engineering problems presented to this group includes investigations of design problems in dams, power plants, pumping plants, canal structures, and similar engineering features related to the Bureau's extensive program. A particularly important function of the group is the analysis of broad phases of certain problems that arise from the unprecedented size or complexity of Bureau structures. As the usual methods of engineering practice cannot always be utilized in these particular instances, this group makes a thorough study of available data and theory and then, together with re-

sults from its own investigations, extrapolates available engineering knowledge into the more difficult problems presented. Thus the group provides solutions to problems requiring immediate attention and also assembles data and prepares comprehensive reports which can be used in future work.

We have many examples of this latter type of endeavor that have gained the Bureau prestige in certain fields of the engineering profession. Our work on stability of dams, earthquake analyses, waterhammer theory, stress analyses of spherical, conical, and circular shells, and other theoretical investigations, represent major contributions to the profession.

I believe that as teachers of mathematics you will be interested to know that a problem in applied engineering mathematics embraces four distinct phases of attack: First, the engineering terms must be translated into mathematical terms; second, the mathematical problem has to be properly stated; third, the mathematical solution must be found; and fourth, the solution must be translated back into engineering concepts. I should like to explain these four steps in more detail.

First, the engineering data require translation into mathematical symbols. In our particular experience, the data are furnished to us from various design divisions within the Branch of Design and Construction, with all pertinent features of the problem clearly stated. Also furnished to us is the presumed accuracy of the data, and usually a reference is made as to the allowable tolerance in the data and the relative magnitude of the quantities involved, the desired order of accuracy in the solution, and any permissible assumptions that can be made. In order to be of value the final date or deadline for the completion of the solution is also indicated at this time.

Second, in preparing the mathematical problem for solution it is necessary to examine the possible methods of approach and select that most appropriate. In most instances this requires a review of basic mathematics. Higher mathematical procedures may also be suggested at this time. Many of the problems encountered in our group reduce to the solution of differential equations, and as certain constants of integration must be evaluated, it is important that the problem has been properly set up before a solution is attempted. This requires broad experience and background in determining whether all given conditions are met, which of the variables should be eliminated, and which should be chosen as the basic unknowns. This formulation of a mathematical problem is the most important step in the solution of most mathematical problems.

Third, in approaching the mathematical solution of a particular problem, our group finds a variety of methods and techniques availa-

ble. In general, the classical methods of approach are most fruitful. However, where possible we also rely upon empirical methods, graphical methods, numerical integration and experimental devices for the actual solution of a problem. We have found in many instances that the use of ordinary numerical integration has repeatedly shown that adequate answers can be readily found to the most complicated problems in all branches of engineering. The basic principles are few and are more easily mastered because the individual steps involve only straight forward arithmetic.

Fourth, we recognize the importance of translating the mathematical solution back into the engineering concepts. The busy designing engineer must have the solution to his particular problem presented, clearly and concisely, so that the equations and numerical values derived by our mathematical analysis group can be intelligently translated into the completed designs. An important responsibility of our group in this regard is to prepare complete engineering reports, together with necessary data, graphs, and charts so that the designing engineer may easily and readily adapt the more complex solutions to his designs. It must be recognized at this point that in the engineering profession there is a conservatism which is forced upon it by the hard facts of life. For example if the mathematician makes an error, then, apart from his reputation the greatest loss is a sheet of paper. On the other hand if an engineering design is unsuccessful, then, not only is the engineer's reputation impaired but there may also be a considerable loss of capital and possible loss of life.

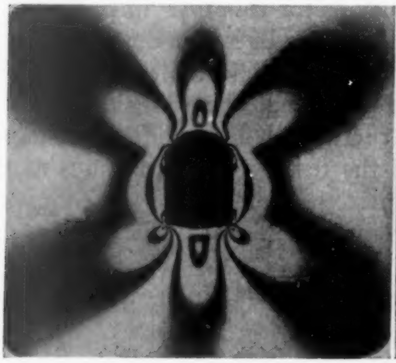
We realize, of course, that many engineering problems are not directly susceptible to mathematical analysis and that certain qualifying assumptions often must be made in order to obtain a solution. This is particularly true in the design of many Bureau structures where there is lack of precedent on which to base a definite conclusion. The soundness or usefulness of the results obtained will then depend largely upon the wisdom with which the original assumptions were made. There is no simple guiding principle which may be applied when deciding upon the initial permissible assumptions. Their selection depends to a great extent upon the understanding of the forces and materials involved, as well as a sound grasp of fundamental engineering principles. Thus, the Mathematical Analysis Group attempts to bridge the gap which separates the mathematician from the engineer by presenting to the designing engineer the results of careful consideration of the physical limitations imposed as well as a workable solution to the problem in question.

The practical mathematical engineer must at all times be cognizant of improved laboratory techniques for solving certain problems which are difficult of rigorous mathematical solution. For example, in addi-

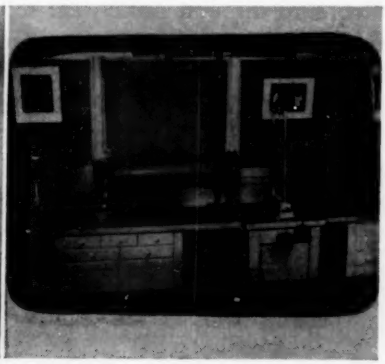
tion to our activities in the solution of engineering problems requiring rigorous analytical mathematical techniques, we have established a photoelastic laboratory to assist in the solutions of certain types of two-dimensional problems in stress analysis of structures which are too difficult or time-consuming for solution by classical mathematical methods. As the exact stresses of these structures are the immediate concern of the designer, and are difficult to cope with analytically, we rely to a considerable extent upon the photoelastic methods for their evaluation.

In brief, photoelasticity is the study of elastic stresses by means of the photographic measurements of the stresses produced in a transparent resinous model, the values of the stresses being determined by the extent to which the transparent model becomes double refracting under an imposed load. This refraction is accomplished by polarized light which is passed through the stressed model to form a "fringe pattern" which can be evaluated in terms of stress. As the models which are made to scale, bear a definite proportionate relation to the prototypes, we can translate the stresses of the models in terms of the prototype structure.

The following slide (No. 1) illustrates the "fringe pattern" around an inspection gallery in a concrete gravity dam constructed by the



Slide No. 1. "Fringe Pattern."

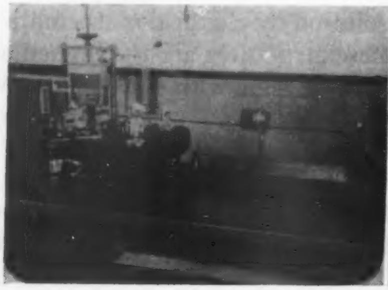


Slide No. 2. The Polariscope.

Bureau. Stresses in this particular example are due to the weight of the dead load of the concrete. The next slide (No. 2) shows the polariscope which is the photoelastic instrument used in our laboratory to study these fringe patterns.

The next slide (No. 3) illustrates the Bureau of Reclamation's interferometer, another photoelastic apparatus for experimentally determining the magnitude and direction of the principal stresses at any point in a structure.

It may be interesting to note that application of these two photo-elastic instruments to certain problems gives solutions to a fourth order partial differential equation.



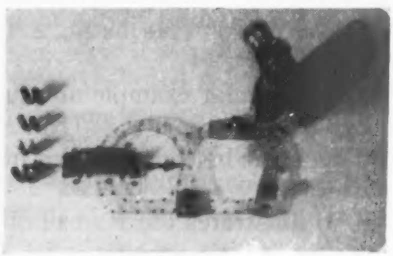
SLIDE No. 3. The Interferometer.

SLIDE No. 4. The Electric Analogy Tray.

Another experimental device in use in our laboratory is the electric analogy tray shown in this next slide (No. 4). This apparatus is very useful for solving problems arising in the field of potential flow, particularly in the branch dealing with the steady state flow of water through earth masses. Solutions for Laplace's partial differential equation of the second order can be obtained by application of this device, and difficult analytical solutions for this type of problem involving functions of a complex variable can be avoided.

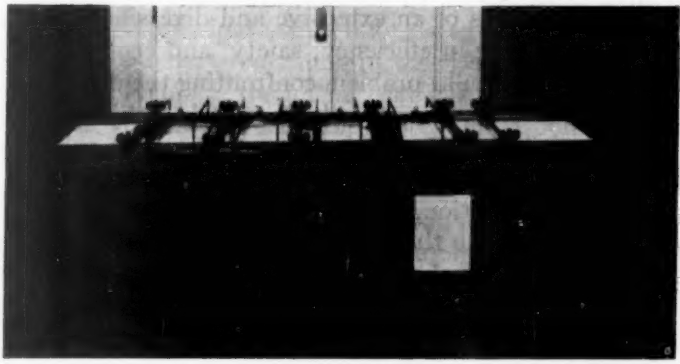
A fourth experimental device is the Beggs deformeter. The deformeter permits the analysis of two-dimensional elastic scale models of various statically indeterminate structures. Known deformations are applied at a cut in the model and the resulting deformations at the load points are read by means of micrometer microscopes. By means of the simple work equation, the unknown stress at the cut section can be found.

The application of the Beggs deformeter to a model of a conduit is shown in the next slide (No. 5).



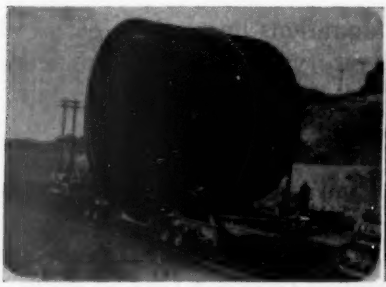
SLIDE No. 5. The Beggs Deformeter.

A useful mechanical aid which is sometimes used to solve mathematical problems is the Reflex Integraph which is shown on the slide (No. 6). This consists of four mechanical integrators interconnected

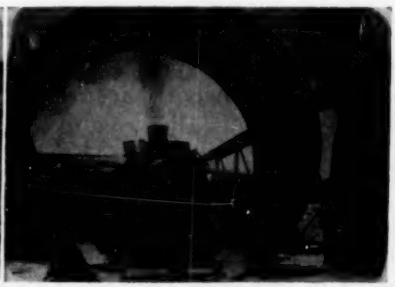


SLIDE No. 6. The Reflex Integraph.

electrically so as to make possible the solution of linear differential equations with constant coefficients of the fourth or lower order. The solution is obtained in the form of a graph on cross-section paper from which numerical values may be read by scale. In many engineering problems the magnitude of the first maximum or minimum of a function may be required, and this can be obtained from the graph without the necessity of long computations. It has also been found possible to solve some types of non-linear equations by an iteration procedure, the process converging quite rapidly to the true solution in most instances.



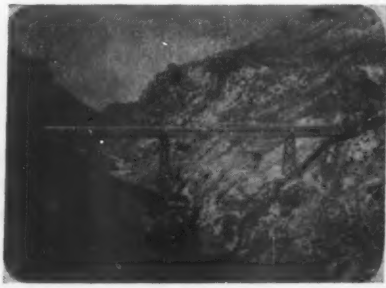
SLIDE No. 7. Section of 30′ dia. steel Penstock for Hoover Dam being moved by trailer.



SLIDE No. 8. Section of 30′ dia. steel Penstock for Hoover Dam in storage yard.

I should now like to show you slides (Nos. 7 and 8) of a few Bureau of Reclamation structures, in the design of which, our mathematical Analysis Group have actively participated. The next two slides illus-

trate a section of a Hoover Dam penstock which conveys water to the power plant and outlet works. This section of steel pipe is 30 feet in diameter and weighs nearly 150 tons. The unusual size of the steel pipe introduced many new problems and intensified many usual ones requiring investigations of an extensive and diversified character to insure that the utmost in efficiency, safety, and economy had been maintained. The particular problem confronting the designer was the design of a 30-foot-diameter pipe which could be subjected to hydrostatic pressure of about 250 pounds per square inch. In order to arrive at a determination of the maximum pressures which would be encountered during operation, studies were made of the waterhammer or pressure surges due to the turbine gate operation. In determining the stresses in the pipe shell considerable study and new developments were required in the theory of elasticity. During this phase of the work a considerable amount of the work resulted in the solution



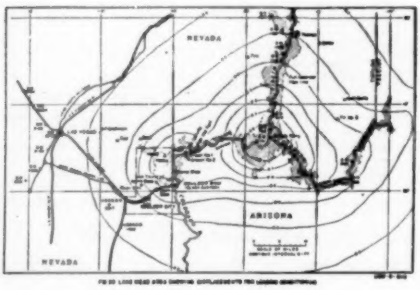
SLIDE NO. 9. Siphon—150′ span across Shoshone River, Wyoming.

SLIDE NO. 10. Hoover Dam.

of complicated partial differential equations up to the eighth order. Before building the actual pipe the theory was applied to models and found to be sufficiently accurate to proceed with the final designs. Incidentally the installed cost of this pipe line was in excess of 12 million dollars.

It often happens that the mathematical studies which have been made for a special problem can be extended to solve other problems. For example consider the design of the pipe line or siphon which is shown in this slide (No. 9). This siphon crosses a canyon about 300 feet wide on the Shoshone River in Wyoming. It has a 150-foot span across its supports and is the longest self-supporting steel pipe in use on a Bureau project. Conventional design would have required the construction of trestles to support the pipe. However, the theory which was developed for the design of the Hoover Dam penstocks indicated that the pipe line could be designed to be self-supporting.

Typical of the many problems on Bureau of Reclamation Projects for which there was no precedent to aid in the design of particular features, was the design of the system for artificially cooling the mass concrete in Hoover Dam which is shown on the slide (No. 10). At Hoover Dam, the principal factor influencing the mass concrete design was the excess heat remaining in the concrete after placement. This excess heat is due to the initial heat in the materials and to the additional heat generated during the process of hardening. Estimates showed that more than 100 years would be required for the excess heat in the interior of the dam to be dissipated by natural processes. Mathematical studies involving the solution of integral equations indicated that a program of artificial cooling of the mass concrete together with the use of a low-heat cement was the most feasible method of solving this problem.



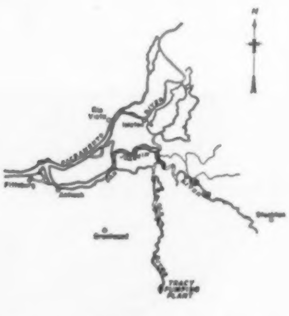
SLIDE No. 11. Map showing displacement in vicinity of Lake Mead.

SLIDE No. 12. Map showing Sacramento and San Joaquin Rivers in California.

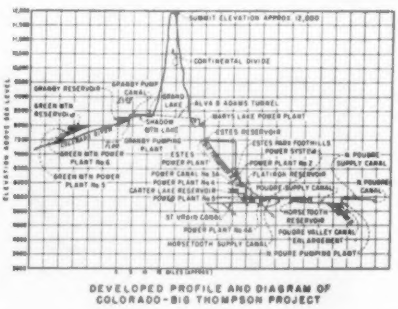
Another unusual problem in the design of Hoover Dam was the determination of the effect on the earth's crust of about 41.5 billion tons of water in Lake Mead (No. 11), the reservoir upstream from the dam. Although normally the increased weight of water in a reservoir impounded behind a dam is insignificant on the earth as a whole the enormous weight of the water in Lake Mead and the possibility of earthquake shocks which could be transmitted to the dam were of concern to the designers. Accordingly, mathematical analyses were undertaken to determine the amount of depression in the earth's surface caused by the weight of the water in the reservoir. These analyses showed that the depression in the vicinity of the reservoir would be about one foot.

An interesting problem currently under consideration by our group is the analysis of the Delta Cross Channel, a key feature of the Bu-

reau's Central Valley Project which is located near Antioch, California (No. 12). The purpose of this important artery is to transfer water from the Sacramento River to the San Joaquin River for eventual irrigation use. As the channel traverses an area at the tidal estuary of the two rivers, consideration was given to the possibility of utilizing the tidal effect to aid in the transfer of water (No. 13). The mathematical theories underlying tidal action, canal hydraulics, and classical mathematical methods are being explored thoroughly to estimate the amount of water which can be pumped through utilization of the gravitational effects of the sun and moon. To our knowledge, this is one of the first instances wherein the Bureau has investigated the possible use of the sun's and the moon's gravitational forces to pump water.



SLIDE NO. 13. Map showing area at intersection of Sacramento and San Joaquin Rivers.



SLIDE NO. 14. Profile of Colorado Big Thompson Project.

Among other current problems under consideration are the many and varied problems of the Colorado Big Thompson Project (No. 14), which incidentally is located about 100 miles from Denver. The following slide indicates the long tunnels, canals, pipe lines, dams, power plants, and pumping plants which are a part of this project. These structures present many unusual problems of the nonrecurring type in engineering mathematics.

I believe that these few examples of some of the more interesting mathematical problems that have confronted us will give you an understanding of the great diversity of our engineering problems. Under the Bureau's present program of design and construction for the development of natural resources throughout the West, we expect many more challenging and interesting problems, which will broaden our experiences and contribute to the field of applied engineering mathematics.

Unfortunately one of the greatest obstacles to success on the part of the enlightened engineer is the attitude of many engineering text-

books towards mathematics. The impression they convey is that advanced mathematics should be avoided by most engineers rather than to be used wherever possible to improve efficiency. A very moderate amount of experience in engineering will convince most engineers that the greatest progress in engineering is made when mathematical interpretations are combined with established practical considerations.

TECHNIQUES AND VALUES OF FIELD TRIPS*

GRACE C. MADDUX
Cleveland Public Schools, Cleveland, Ohio

Many teachers hesitate to take children on field trips. That, of course, is not surprising since there are many problems involved.

The traditional teacher is reluctant to get away from her four walls, the blackboard, and her textbooks. She feels secure there; but the thought of taking a class into the wide open spaces is appalling. She wonders what she can do with a class in the open and whether the pupils will learn anything.

Sometimes school administrators are not convinced of the value of trips; they may also object to having the time schedule interrupted. Often colleagues in a departmental setup will not cooperate in excusing a class for a period. They say that they can't "cover the assignment" if classes miss a period of mathematics or history.

Teachers may ask, "Can anything be gained on a field trip that cannot be accomplished as well in the classroom?" An answer depends, in part, on the subject being taught, the amount of visual material that can be brought into the classroom, and the type of environment in which the school is located.

In studying trees, children may learn to identify leaves in the classroom. However, it is better to go outdoors and see the entire tree and learn to associate the leaves, bark, and shape with a particular species.

A geology unit, at any level of ability, is certainly much more meaningful after a trip to local rock exposures. A piece of granite or shale in the classroom gives a very incomplete idea of the appearance of these rocks as an integral part of the earth.

"Shale" means more to a group of children who have tried to climb a crumbly shale bank. They can readily see that it is a clay-like material when they moisten it in the water of a stream. The statement that sedimentary rock is in layers doesn't need much teaching when they

* Presented to the Elementary Science Section of the Central Association of Science and Mathematics Teachers at Chicago, November 25, 1949.

see the layers of sandstone or shale on an exposed bank. It is easy to teach erosion when children can see examples in the field and can discover the effect of forces of erosion on soft rock.

Concepts about farm animals or good agricultural practices become meaningful to children who have visited a farm.

Children may report that they have seen the constellations which you are discussing in class. An evening spent with them in the school yard will convince you that the majority are merely trying to "please teacher." They themselves have really never located the constellations; hence an evening of star gazing with a class in the school yard is worth the time and effort.

A study of insects from the point of view of their value or harm to man is in most courses of study. A trip with children to likely places to find and catch insects is always worth while. Collecting insects satisfies a natural instinct to collect and it may lead to a worth while hobby.

A zoo is an excellent place for children to become acquainted with wild animals not common in their environment. Just pictures of these animals may often leave children with false concepts as to relative size, color, or thickness of hair.

Some teachers are able to have very effective bird trips. Such trips require special planning because birds are frequently difficult to observe. Careful planning of such trips will eliminate many of the problems involved.

In planning with the children, the first step is for them to see the need for the trip. When they understand the purpose they will enter into the spirit of the plans. If the children are included in the planning of each step, the trip will be successful, because they will see the reason for certain conduct and procedures.

The length of the trip depends on the purpose and the location. You may have a trip to the school yard or nearby streets to study trees. That may require just one period. Some trips may require a half day or a whole day.

When the class has decided on the need for first hand observation and has chosen the location and date for the trip, it is necessary to get permission from the principal and parents. If a guide is available at the place to be visited, that person must be contacted for permission and confirmation of the date. This affords opportunity for letter writing.

If transportation is necessary, that is another problem to be solved. Some schools have their own busses so there is no problem except to arrange for the time. Schools without such transportation have to rely on local streetcars or buses, a chartered bus, or the cooperation of parents with machines.

Some of these plans require money. This may stimulate a worthwhile activity to raise money.

Another step in planning is to decide what to take along. Notebooks and pencils are usually necessary. Other equipment may be—paper bags or baskets to collect rocks on a geology trip; a large magazine to press leaves or flowers; an insect net and killing jar for insect trips; field glasses for birds or star gazing; dip nets, strainers, and glass jars for collecting pond life. Some children may want to bring a camera. All day trips will, of course, require a lunch.

The type of clothing to be worn should also be discussed. Clothing suitable for the weather brings out good health practices. Old clothes and comfortable shoes are usually in order. Slacks are good on trips when the children may do some climbing.

If the children have a thorough understanding of the purpose of the trip, the problem of conduct is not so difficult. However, there are always certain standards to be set such as, courtesy to the teacher or any member of the group who is talking; the problem of keeping together with the leader at the head of the group; not interfering with any member of the group; the need of following directions exactly; and the need for practicing safety.

These standards can be achieved if the children realize that a field trip is a lesson out-doors, in the best of all possible laboratories, and that the same rules of conduct hold, that are necessary for learning in a classroom.

Some teachers prepare guide sheets to direct the work on a field trip. Sometimes it is best to work with the entire group. Some situations may lend themselves to small groups working on a specific problem or question. If groups are to be used the plan should be made in advance.

A field trip, as a rule, should not be too general, but should be planned to enrich a particular unit being studied in the classroom. A field trip should not, however, be so narrow and so planned that the teacher does not take advantage of interesting things along the way such as a bird or any unusual animal or plant. It isn't always possible to plan ahead of time just what will happen. Children's questions should be answered if possible.

The children should see more than just the specific material relative to the purpose of the trip. In that way they realize that nature is all inclusive and it is difficult to isolate a particular part of it for study. Inter-relationship of plant and animal life can often be pointed out.

The follow up and evaluation of the trip after they get back to school is most important. It should be the starting point for many activities. The children should be aware of the facts learned and

relate them to the unit under consideration in the classroom.

The field trip was primarily to gain certain facts in science. However, many of the desirable intangible purposes of education such as courtesy cooperation, and good citizenship are also achieved. The trip may also furnish meaningful material for other subject matter areas such as arithmetic, English, health, safety, and art.

Last, but certainly not least, the teacher has the opportunity of getting better acquainted with her children in the more informal atmosphere out-of-doors.

Try a field trip some time and convince yourself of its educational value.

NATIONAL TEACHER EXAMINATIONS WILL BE HELD ON FEBRUARY 18, 1950

The National Teacher Examinations, prepared and administered annually by Educational Testing Service, under sponsorship of the American Council on Education, will be given at testing centers throughout the United States on Saturday, February 18, 1950.

At the one-day testing session a candidate may take the Common Examinations, which include tests in General Culture, Mental Abilities and Basic Skills, and Professional Information; and one of eleven Optional Examinations, designed to demonstrate mastery of subject matter to be taught. The college which a candidate is attending or the school system in which he is seeking employment will advise him whether he must offer the National Teacher Examinations and which of the tests he should take.

Application forms, and a Bulletin of Information describing registration procedure and containing sample test questions, may be obtained from college officials, school superintendents, or directly from Educational Testing Service, P. O. Box 592, Princeton, New Jersey. A completed application, accompanied by the proper examination fee, should reach the ETS office not later than January 20, 1950.

NEW REPEATING PHOTOGRAPHIC FLASHTUBE TAKES MANY PICTURES AT HIGH RATE

A new repeating flashtube for photographers, revealed by the General Electric Company, is capable of taking thousands of pictures at speeds of one-5,000th of a second, it is claimed.

It is described as a relatively low-voltage, 100 watt-second flashtube of high efficiency. Its flash duration has 10 times the action-stopping power of the fastest shutter now in general use, making it possible to take sharp pictures of even the fastest moving object. The tube produces ample quantities of light for close-up color photography.

The new tube, designated the FT-110, is said to be the first flashtube designed to operate in the 800- to 1,000-volt range. It is filled with xenon, a rare gaseous element of the atmosphere. This gas results in light of day light quality. Another factor contributing to the high photographic effectiveness of the new unit is a reflector of special design. The tube is used in connection with an improved triggering circuit.

DESIRABLE QUALITIES IN DEMONSTRATION APPARATUS

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With the end of the war and the removal of the bothersome priorities, with the domestic production lagging far behind the demand and manufacturers of science apparatus still in the stages of reconversion, with foreign production still far from competing or even stimulating home production, with accumulated funds available and apparatus mostly unobtainable, would it not be wise to pause and take stock of just what qualities we science teachers can expect in our demonstration equipment, rather than heedlessly to rush in and buy the first offerings?

"Although abundant in quantity, the sensory-aid materials are very heterogeneous. This condition poses problems relating to selection and effective use of these aids. It also suggests the need of references to which the teacher can turn for evaluation of the different types of materials. Much of the evaluation now available is in terms of general platitudes which are not very helpful."[1]

The last war has left us in a state of mental confusion. We science teachers, trained to observation and evaluation, should be able in our own interests to make such an evaluation of the tools of our trade, the demonstration apparatus.

The making of this evaluation poses the problem: just what are the desirable qualities that we expect in our demonstration equipment? This problem can be broken down into components, which individually are more easily solved. Prescinding from all the particular sciences: 1. Are there definite qualities inherent in demonstration apparatus? 2. Can these qualities be objectively determined? 3. How can the existence of such qualities be validated? 4. Can science demonstration apparatus be evaluated by criteria?

That the lecture-demonstration method is still in honor is immediately evident when we observe the publication of large collections of such experiments in both physics and chemistry within the last ten years, and the revision of earlier publications within the same span.

"Teaching by the demonstration method is an important part of science instruction . . . it is being more widely used in science than ever before."[2]

Potthoff[3] in his article, "The Use of Demonstrations in Science Teaching," concludes that there are many values in demonstration

[1] The Forty-Sixth Yearbook of the National Society for the Study of Education. Part I, *Science Education in the American Schools*, p. 208.

[2] *Ibid.*, p. 236.

[3] Potthoff, Edward F. "The Use of Demonstrations in Science Teaching." *Science Education*, 29: 253–255, Dec. 1945.

methods. The Forty-Sixth Yearbook[4] of the National Society for the Study of Education gives five situations where demonstrations should be used.

"Demonstrations should be used mainly in problem-solving situations—problems that demand the finding of certain facts, ...
"Demonstrations may be used to raise and define worthwhile problems.
"Demonstrations may be used in collecting data and developing skill in the interpretation of data.
"Demonstrations may be used to test our pupils' hypothesis.
"Demonstrations may be used to illustrate the applications of principles."

The authors of methodologies for the teaching of science are also aware of the need of demonstrations.

" . . . one earmark of an effective teacher of science is the ability to 'put on a good demonstration.' This ability may not be entirely indispensable but to have it is a great asset to the science teacher. . . . "[5]

The part that demonstrations are to play in the teaching of science will depend to a large degree on the philosophy of the science teacher. Since it is the roll of philosophy to determine basic principles and through them to influence attitude and habit and thus also procedure, it is evident that the different systems of philosophy will give different degrees of emphasis to the techniques of demonstration. Without entering into thorough discussions of aims, objectives, purposes and disciplines, we can premise that one of the prime aims of all science teaching is student acquisition of precision and accuracy. If this is granted, and this aim is kept in mind, there will be developed in the student habits and attitudes classed as scientific, e.g., 1. adequate observation and experimentation; 2. the formulation of hypotheses or generalizations only in so far as the experimental data warrant; 3. testing of the hypothesis; and 4. suspending of judgment till validating evidence is produced. This enumeration is not meant to be an exhaustive one. The changes we propose to effect in the attitudes of students are: 1. a better adjustment to modern social order; 2. a better understanding and appreciation of the findings of science; 3. sympathy and support to further scientific research. Neither is this second enumeration to be considered complete.

Frequently enough the plea is made that good equipment also requires expert handling of the apparatus. This plea continues that no matter how good the equipment may be, a poor preparation, a lack of try-out, or the failure to demonstrate the cause-effect sequence can nullify the best qualities inherent in apparatus. Thus Selberg[6] found

[4] *Op. cit.*, pp. 236–238.
[5] Noll, Victor H. *The Teaching of Science in Elementary and Secondary Schools.* New York: Longmans, Green and Co., 1939, p. 44.
[6] Selberg, Edith M. "A Plan for Developing a Better Technique in Giving Science Demonstrations." *Science Education*, 16: 417–420, Oct. 1932.

sixteen errors of procedure to account for the failure of beginning science teachers to achieve maximum results from their demonstrations. Potthoff,[7] when considering what might hamper the achievement of the predetermined values for demonstrations, concludes that the cause is partly in the qualities inherent in the apparatus, and partly in the conditions necessary to good performance.

"The success of any method in teaching science depends, in a large measure, upon the teacher's skill with that method. All science teachers should be thoroughly familiar with the basic principles useful as a guide in doing demonstrations."[8]

Qualities at times ascribed to apparatus are but the qualities of a good procedure or technique. It is not too difficult to distinguish good procedure from qualities inherent in the material apparatus.[9]

It is essential to define terms in the discussion. As many definitions of *demonstration* will be found as there are authors treating the subject. Preston[10] realized this and made a plea for unification and clarification of terminology. His own definition of demonstration is: "Lecture-demonstration should be applied to class meetings . . . at which the audience is shown something, usually specimens or phenomena, in addition to the spoken word."

One of the dictionary definitions of *demonstration* includes the concept of a salesman's demonstration of wares for sale. Another more categorical definition states that by demonstration is meant: to show or prove to the mind or understanding.

Inherent in the concept of demonstration is the factor of *movement* of a *material thing*, not a static condition or display. Demonstration is an appeal through the senses of *sight* and of *hearing*, and less frequently through the other senses. Results must follow the purpose: there must be conviction, compelling to an inescapable conclusion.

The term *apparatus* next stands ready for definition. If the definition developed above is accepted in its narrowest sense, certain standard teaching materials are thereby automatically excluded, e.g., *objects*, unless they can be operated. Objects are reality and as such convincing because of inherent truth; so also *specimens*, or *samples*, *parts*. These latter would only be displays or exhibits, because they are not dynamic. Likewise *models* as such are barred unless they are working models; so also are miniatures or enlargements. *Pictures*, *charts*, *transparencies* are likewise to be excluded because they appeal to but one

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[7] Potthoff, *op. cit.*

[8] The Forty-Sixth Yearbook N.S.S. Ed., p. 236.

[9] Hitchcock, Richard C. "The Nature of Lecture Demonstrations in Physics" *Science Education*, 23: 313–327, Nov. 1939.

Gramet, Charles A. "Demonstration Lessons in Biology." *Science Education*, 18: 33–36, Feb. 1934.

[10] Preston, Carleton E. "Is The Debate in Common Terms?" *Science Education*, 19: 14–16, Feb. 1935.

sense—sight. *Recordings* and *radio reproductions* can so be excluded, because they appeal to but one sense—hearing.

Most readers would not agree to hamper their teaching by these limitations of terms. There is, no doubt, great value in models and specimens for such a science as biology, but only when their display is implemented by the spoken word. But even models, specimens and charts lack determinable, desirable qualities, which lack detracts from their use and value. By the same token, they can have undesirable qualities that detract from the efficiency of their use.

The dictionary definition of demonstration contains among its varieties several common elements: *action* or *movement*, appeal to the *mind* or to the *understanding*, and *conviction* or *cooperation* as the result of the former two elements. Thus we have three fundamental qualities determined by definition. Add to this that the demonstrations of science have always been of *material things*, or of a concept illustrated by material things, and a fourth quality becomes evident. Thus the first subdivision of our problem, Are there definite qualities inherent in demonstration apparatus? is capable of solution.

Another way of discovering the qualities desirable in demonstration apparatus is the discussion or mention by teachers, the users of demonstration equipment in books and in experimental manuals, in methodologies of science, and in audio-visual manuals and texts. Still another way to discover such qualities is the perusal of the teachers' writings in their professional journals, or their contributions to yearbooks and publications of science, committee reports, discussions among themselves at their conventions and club meetings, suggestions to manufacturers and designers of apparatus, and finally, the observations and comments by any teacher who uses the lecture demonstration method and makes a subjective appraisal or evaluation of his tools.

Investigation of the source of information—the *suggestions by teachers to manufacturers*—has been disappointing. The manufacturers interviewed at the C.A.S.M.T. 1947 convention admitted that they had no known list of qualities or criteria that their products had to meet. The manufacturers claimed that while they had had much discussion on every piece of apparatus they produced before it was offered to the public, yet they had no written list of criteria by which to judge their products. When questioned on how equipment originated, they admitted that some small part came at the suggestions of teachers.

Perusal of old supply-house catalogues brought only one acknowledged series of aims. In the 1923 edition, Catalog F of Cenco, we find four out of six items to be very pertinent to this study:

First: new equipment demands that apparatus be kept up to date.

Second: simplification or reduction in cost without loss to appearances and in performance.
Third: low selling price with only a small margin of profit over manufacturing costs.
Fourth: manufacturing standards of excellence maintained through inspection of products.

On a following page are also stressed such terms as dependability (reliability of performance), standardization and simplification.

Survey of the Related Literature

As the *Education Index* begins with January 1929, it covers at this time twenty years. Through the references contained in its contents the literature of another few years to 1925[11] may be reached.

Some journal articles with the most promising titles turned out to be worthless. By a compensatory turn, articles with titles that gave small promise of being useful turned out to be veritable gold mines. The general methodologies on the teaching of science, and those which concerned themselves with particular sciences were devoted to matters other than the qualities of demonstration equipment. Some of these books were found to be definitely antagonistic to the lecture-demonstration method. Other books purporting to be collections of experiments made mention of general qualities desirable in demonstration apparatus, but relegated such information to prefaces, introductions, forewords, etc.

One of the early milestones in the thought on this problem was a casual three-quarter page report in School Science and Mathematics in 1928 of A. W. Duff's[12] remarks at the May Meeting of the Eastern Association of Physics Teachers enumerating nine characteristics of demonstration equipment with examples of each. This article, however, referred to physics only. Gould[13] in 1931 listed eight qualities for demonstration experiments in chemistry. Gramet[14] (1934) found eight characteristics for good apparatus in biology. Barnes[15] (1935) in a doctoral dissertation, "Criteria for the Selection of Science Teaching Materials," validating his findings by recourse to competent authority, found that of his twenty-eight criteria seven had high validity. Dunbar[16] (1936) basing his work on the report of Duff

[11] Davison, H. F. "The Art of Lecture Table Demonstrating." *Journal of Chemical Education*, 2: 443–447, June 1925.

[12] Duff, A. W. "Desirable Qualities in Demonstration Experiments." School Science and Mathematics, 28: 857, Nov. 1928.

[13] Gould, Arthur B. "Demonstration Experiments and Their Place in the Teaching of Chemistry." *Journal of Chemical Education*, 8: 296–302, Feb. 1931.

[14] *Op. cit.*

[15] Barnes, Cyrus W. "Criteria for the Selection of Science Teaching Materials." *Science Education*, 19: 152–157, Dec. 1935.

[16] Dunbar, Ralph E. "Some Desirable Characteristics in Chemistry Demonstration. Experiments." School Science and Mathematics, 36: 635–637, June 1936.

did a similar job, but for chemistry, and claimed eleven qualities for demonstration apparatus. Hitchcock[17] (1939) makes a lengthy plea for good physical conditions under which to conduct demonstrations, and also offered six criteria with which to evaluate good demonstration techniques. Recently, Ott[18] (1946) advocated both microtechniques and projection. Two outstanding studies of inspirational value are the Thirty-First and the Forty-Sixth Yearbooks of the National Society for the Study of Education. Sutton[19] most recently (1941 and 1948) lists ten qualities which he classifies under *Simplicity* but which contain more than just this one quality. The lesser contributions are listed in the bibliography.

From our experience in carefully combing the *Education Index* as well as from the admitted experience of others, there are but three outstanding journals that have carried the burden of reporting the thought, experience, and findings of science teachers at the high school level, the *Journal of Chemical Education*, *Science Education*, and SCHOOL SCIENCE AND MATHEMATICS. A careful winnowing of all sources has turned up twenty books and committee reports that definitely are helpful in this study, and among the journals thirty articles which have aided in the solution of this problem.

The workers in neighboring fields have been even more sensitive to the need to evaluate the materials of instruction. Thus Holy and Sutton[20] in 1931 endeavoring to determine minimum science equipment canvassed outstanding teachers of science in forty-eight states. The Eighth Yearbook of the Department of Supervisors and Directors of Instruction of the N.E.A. found eight criteria for evaluating the *Materials of Instruction*. No listing of accessory teaching materials would be complete that neglected to mention the study made by Heiss, Obourn, and Hoffman[21] in 1940. In 1941 Joseph[22] published the findings of his doctoral dissertation in a *Sourcebook of Extra-Curricular Activities in Physical Science for Senior High Schools*, and reported six of his eleven criteria, validated by expert judgment of competent authority, to be highly significant.

The workers in the audio-visual field have endeavored mightily to

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[17] *Op. cit.*

[18] Ott, Margaret A. "Microtechniques for Projection Demonstrations in General Science." SCHOOL SCIENCE AND MATHEMATICS, 46: 68–73, Jan. 1946.

[19] Sutton, Richard M. "The Importance of Scientific Instruments and Apparatus to the Teacher of Physics." *Review of Scientific Instruments*, 12: 563–582, Dec. 1941.

———, "Simplicity in Demonstrating Physics." *The Science Teacher*, 15: 22–39, Feb.; 63–65, April; 112–113, Oct. 1948.

[20] Holy, T. C. and Sutton, D. H. "Determining Essential Apparatus." *Educational Research Bulletin*, 10: 171–177, April 1, 1931.

[21] Heiss, Elwood D., Obourn, Ellsworth S., and Hoffman, G. Wesley. *Modern Methods and Materials for Teaching Science*. New York: The Macmillan Company, 1940, pp. 33, 69.

[22] Joseph, Alexander. "Developing a Sourcebook of Extra-Curricular Activities in Physical Science for Senior High Schools." *Science Education*, 26: 84–93, Feb. 1942.

evaluate their materials.[23] Most recently attempts have been made to evaluate free and inexpensive materials offered by commercial houses.[24] This work has also been of high order. The authors of recent physics texts[25] are acutely conscious of the teaching value of demonstration experiments. Furthermore, they are aware of certain qualities inherent or desirable in demonstration equipment, as is evidenced by the terms they use in their descriptions: ***skillful, well-chosen, arouse interest, drive home, adapted, saving time, select, ineffective, spectacular, vivid, clear***, and ***teaching value.***

The first problem, that of discovering the sources or listings of qualities in demonstration apparatus having been solved, the second problem of validating criteria can be answered by recourse to the same sources, the journal articles and texts on demonstration experiments. While at times the authors reporting new experiments or adaptations of older ones emphasize one or two qualities, other authors have consciously tried to list all qualities desirable in demonstration apparatus. Such listings were done, however, mainly on a subjective evaluation basis. But the concordance of many such subjective evaluations of users, inventors, adaptors surely furnishes a valid criterion. No frequency-of-mention tabulation was made or kept by the writer. A frequency-of-mention of ***one*** was all that was needed for acceptance and inclusion. Both from memory and from the abstractions made, it is evident that the authors in journal articles are much more conscious of some qualities than of others. For example, ***use*** and *cost*, conflicting considerations, are of most frequent mention, while *safety* is the least frequently mentioned. Neither would a high frequency-of-mention count add any importance to a quality not already inherent in that quality.

This last consideration leads us to a listing of these qualities in order of their importance. It seems self-evident that there be extrinsic as well as intrinsic qualities. Among the extrinsic might be listed: 1. the designer's or inventor's reputation as a scientist; 2. the manufacturer's or distributor's reputation for high quality goods; 3. the revision of design of a previous model, eliminating defects, or extending the use of the apparatus; 4. the chance of such a further revision, or reduction in price; 5. changes in textbooks or laboratory manuals requiring added, new, or different apparatus; 6. adequate covering of the subject matter or filling lacunae in demonstrations; 7. offering

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[23] The Forty-Second Yearbook of the National Society for the Study of Education, Part II, *The Library in General Education*. Chapt. XI, Audio-Visual Aids, pp. 176–218.

[24] *Commercial Supplementary Teaching Materials*, Consumer Education Study of the National Association of Secondary School Principals. Dept. N.E.A., Washington, D. C. 1946.

Specifications for the Commercial Supplementary Teaching Materials for Science. National Science Teachers Association for the National Association of Secondary School Principals. Washington, D. C. 1946.

[25] Burns, Elmer E., Verwiebe, Frank L., and Hazel, Herbert C. *The Physics Teacher's Guide for Use with the Text "Physics, A Basic Science."* New York: D. Van Nostrand Company, Inc., 1944, p. 11.

confirmatory or convergent evidence to other demonstrations or experiments; 8. changes in the curriculum or the policy of the school system.

The intrinsic criteria are the ones with which this study is mostly interested. Their existence is also rather self-evident. Most of the work of this study concerned the identification and classification of intrinsic qualities. The authors of journal articles have used a wide range of expressions covering the same concepts, and at times it is difficult to determine whether the authors meant a slight variation within the general class or whether the expression used is only a variation in language and not in concept. The large areas or categories, easily identifiable and of primary importance judging by their frequency of mention are: need-use, simplicity, visibility, cost, reliability, and showmanship. Of secondary rank in importance and of frequency of mention are: administrative, dynamic, time, durability, and safety.

Some of these titles are complexes: thus, it is difficult to distinguish between NEED and USE; by the same token, SIMPLICITY and SPECIFIC are closely related. The title SHOWMANSHIP, frequently used by authors is difficults at time to differentiate from DYNAMIC; thus also COST and DURABILITY are related.

It is difficult to say what makes a prospective purchaser of demonstration equipment decide in favor of one piece of apparatus rather than another. A problem arises from the presence of conflicting criteria. It is solved on a subjective basis. Illustrations in textbooks often determine choice. So also does cost. Familiarity coming from previous use, whether during student days or from a previous position in other schools where demonstration equipment was used, does influence purchase. Where budgets are limited, the conflict will center upon cost and need. Where funds are generous other considerations come into play, such as showmanship, reliability, time, simplicity. Where classes are small, visibility is not so much a factor. But the authors of journal articles from the very first one (1925) abstracted, give this quality rather strong emphasis. Other authors are more interested in the psychological aspects of teaching and emphasize reliability or performance, with all the possible implications under such a heading. Recommendations by one teacher to another also play an important roll in the choice of science equipment. But while all the above mentioned factors may partially determine choice, rarely are we conscious of the presence of more than two or three of them. To make the choice less subjective, and to make it on the basis of more factors, the findings of this study have been cast into the form of a checklist.

The decision to report the findings of this study in the form of a

checklist was made with misgivings. This modern tool devised for rapid rating, can easily be abused. The dangers lie in the facts of a subjective, momentary decision, often emotional in character, made on the basis of novelty or on sense appeal of color or finish. Then there is also the question of what importance to attach to the possession of high excellence in one criterion as against lower excellence in many criteria, for it will be admitted that there are degrees of excellence possible in each attribute or quality.

Barnes[26] (1935) in his conclusions has:

7. "Certain criteria may be applied in the light of pertinent information found in published research."
8. "Certain criteria may not be applied . . . , but only on a subjective judgment of the degree to which any specific item of teaching material will satisfy a given criteria."

The question of reliability of the findings in such studies as this one has also been considered in the past. Joseph[27] (1942) tried a reliability study with his eleven criteria and concludes that they are consistent on two trials, though allowing for human error to apply the criteria.

Factor is used for those desirable conditions not inherent in apparatus but more in the physical surroundings, and in good techniques. *Qualities* are those characteristics inherent in the materials of the apparatus, or in their assembly, or in the action of the apparatus. By NEEDS we understand any requirement which prompts to action, experienced as desirable. USE connotes taking as a means to desired ends. SHOWMANSHIP, a term so frequently used in the literature of demonstrations, is extrinsic in the operator, but intrinsic in the emotional appeal of novelty, and of inexpectancy of a demonstration. DRAMATIC, often used for showmanship, is mostly extrinsic and in the performer. More difficult and of wider connotation is SIMPLICITY. At times it substitutes for SPECIFIC. It is correctly applied to those pieces of few parts or those requiring little manipulative skill. VISIBILITY has many factors. It is also inherent in the size of the apparatus.

CHECKLIST
(abbreviated)

ADMINISTRATIVE (factors)
- Financial, budgetary considerations.
- Crowding of Classes.
- Elective Course, of temporary popularity.
- Standards of an Accrediting Agency.
- Changes in School Policy.

COST (factors)
- Initial Investment.
- Maintenance.

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26 Barnes, *op. cit.*
27 Joseph, *op. cit.*

Distributed Cost: number of times used; degree of versatility.

DYNAMIC (qualities)
Positive Effects or Motion.
Null Effects or Static Display.
Speed of Performance.

DURABILITY (qualities)
Degrees, from fragile to indestructible.
Weight of Apparatus *against* Ease of Handling.
Stability or Low Center of Gravity.

NEED—USE (qualities)
Judged by Inclusion in Courses of Study, Textbooks, and Demonstration Manuals.
Judged by the School's Philosophy of Education.
To Teach and to Learn: facts, laws, phenomena; interests, attitudes, ideals.
Frequency of Use.

RELIABILITY (qualities)
Uniformity of Results Measured in Accuracy.
Infallibility of Action.
Simplicity of Operation: manipulative skill required; knowledge required.
Accuracy Attainable.
Mechanical Excellence: no constant attention or adjustments.

SAFETY (qualities)
Degrees of Danger.
Kinds of Hazard.
Danger of Breakage.

SHOWMANSHIP (quality)
Emotional Appeal: toys; color; plating.
Appearance: obsolescent; new; attractive.
Dramatic in Performance.

SIMPLICITY—SPECIFIC (quality)
In Design: no distracting parts.
Demonstrates Basic Principles.
Demonstrates One Principle Only.
Related to Previous Common Experiences.
Comprehensive: shows all, not only a part.
Appropriate.
Versatile: can be used in different experiments.

TIME (factors)
To Set Up—not to assemble.
To Dismantle.
Per ONE Measurement or Demonstration.

VISIBILITY (factors)
Light Intensity.
Color Contrast to Background.
Distance to the Student.
Poor Vision.
Colorblindness.

VISIBILITY (qualities)
Size of Apparatus.
Vertical Mounting of the Apparatus.
Number of Parts in the Apparatus.

Models: enlarged or reduced in size.
Print and Labels.
Parts of the Apparatus: crowded, overlapping, masking.

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RATS AND RAT POISON

When man finally rockets to the moon, the chances are that Brother Rat will accompany him.

This was the prediction made by Charles D. Thurmond of Monsanto Chemical Company in a talk here before the Pacific Insecticide Institute during which he reviewed the progress made during the last ten years in discovering and perfecting rat poisons.

"Man is rat's softest touch," Mr. Thurmond said. "He has followed man all over the world and was probably on board the Mayflower. I am sure he will get to the moon, too, and not because he thinks it is made of green cheese."

Poison is the most efficient means of destroying rats, Mr. Thurmond said. He described ten rodenticides (rat killers) which are generally used. Six of them, he said, were in common use prior to the war. The remainder were directly or indirectly the result of war-inspired research to obtain adequate battle-area rat control.

These new rodenticides were listed as Antu and Compound 1080, both developed in this country, and Castrix and a related product developed by German scientists. The German chemicals now are being investigated further in this country.

"RATISTICS" GIVEN BY MR. THURMOND

There are more rats than people in the United States—155 million rats to 150 million people.

The rat has caused mankind more trouble, more expense, more suffering and more death, than all the wars combined.

The annual damage caused by rats has been estimated at $500 million, mostly in agricultural products.

Rats destroy and eat as much food each year as 265,000 farmers produce in the same period.

BEAVERS LIKE CORNSTALKS

Dakota beavers have developed a new taste—for corn—and commonly "harvest" cornstalks from farmers' fields.

Favorite food of beavers is aspen and willow, but they will accept cottonwood, ash, chokecherry and even conifers for food. Only limited numbers of some of these trees grow on the plains, hence the change to a corn diet.

A recent survey of the beaver food caches in North Dakota by the Game and Fish biologists reveals that corn shocks make up a surprising large part of the beavers' food. These "animal engineers" visit fields of shocked corn and carry the stalks to their food caches.

A MATHEMATICIAN LOOKS AT ANATOMY

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The purpose of this article is to show the relationship between mathematics and parts of the human body, especially the resemblance of different parts to the curves of the second and higher degrees. All the illustrations were made from photographs of a real skeleton taken by the author.

Of course, the numerical constants in every skeleton are well known, the number of bones of different kinds being the same in every normal body.

The cranium illustrates some interesting curves. The outline as seen from above conforms to an ellipse. The one which was photographed was fitted to the equation:

$$289x^2+196y^2=14161. \qquad \text{(Figs. 1 and 2)}$$

The line of fusion of the two parietal bones splits the crown lengthwise at right angles to the frontal bone. In the back, the occipital projects in an obtuse angle to meet the parietal bones.

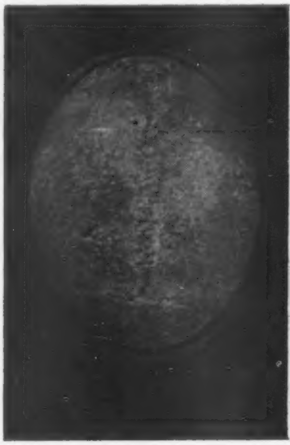

Fig. 1

Fig. 2

A side view of the cranium, if rotated through ninety degrees, is the spiral of Archimedes (Fig. 3), while the front view of the whole skull (Fig. 4) presents four geometric forms: the semicircular crown, the circular bases of the conical orbits, and the parabola which is the outline of the lower jaw, and which in this figure has the equation:

$$x^2=14y.$$

The lower jaw, as seen from above, also fits a parabola. The hyoid bone, located just above the Adam's apple, is another parabola.

Each vertebra of the human spine consists of two parts, a solid ventral portion and a dorsal arch with seven processes. The extremities of the three outer processes form a triangle, and the extremities of two other processes apparently touch the two dorsal sides of this triangle. The cross section of the solid portion is elliptical. An equation,

$$25x^2+64y^2=1600,$$

was found to have a graph which fitted one of these portions.

FIG. 3

FIG. 4

Triangular shapes may be found by connecting many other groups of three points in the skeleton. The shape of the scapula is almost a perfect triangle. At one vertex, it provides the glenoid cavity, or socket, into which the hemispherical head of the humerus articulates. The humerus is roughly cylindrical, while the ulna and radius can be parallel or form vertical angles, depending upon their position. Placing the hand in a horizontal position, the metacarpi of the hand and the phalanges of the fingers permit movement in acute angles, horizontally, while vertically and in other directions, right and obtuse angles may be used.

The sternum is a flat rectangular bone running vertically in front, to which the true ribs are attached. There are seven pairs of true ribs. three pairs of false ribs which are attached to the rib above by cartilages, and two pairs of floating ribs, not attached at all in front.

The pelvic girdle is large and irregularly shaped. It forms the side and front walls of the pelvic cavity, and affords attachment for the

lower extremities. Three bones are fused to form the girdle. The ilium is the prominence of the hips, and has a semi-circular outline viewed from the back and the sides. The ischium is the lower and stronger portion and together with the ilium presents a typical curve of the fourth power, when viewed from the back. The third bone, the pubis, forms the front of the pelvis, and joins the ilium and ischium to form the acetabulum, the socket which receives the hemispherical head of the femur. The subpubic angle in the male is acute; it is obtuse in the female.

Figure 5 shows the pelvic girdle from behind, with the two semicircles of the ilium, and the curve:

$$90y = x^4 - 22x^2 + 40$$

superimposed on the figure.

FIG. 5

The femur is the longest and strongest bone in the human body. The hemispherical head is attached to the cylindrical body at an obtuse angle by a restricted neck. The lower end articulates with the tibia and the patella, or knee cap, a triangular bone which protects the knee. The femur is capable of rotation through an angle greater than one hundred eighty degrees, its rotation being restricted by the body.

The muscles of the human body are perfectly symmetrical about a line bisecting the body longitudinally, and form various geometric figures. Some of these are: the elliptical muscle around the eye, several triangular muscles, the more conventional muscle appearing in two dimensions as a quadrilateral and in three dimensions as a cylinder. They make many vertical and dihedral angles. To these forms the theorems of geometry naturally apply.

Muscles propel the body and are responsible for all motion. The skeletal muscles are almost invariably in pairs, a flexor and an extensor, one counteracting the other. This illustrates the concept of positive and negative numbers. The subject of muscles, by necessity, introduces the subject of levers, the mathematical principles of which are well known.

The central nervous system acts as the switchboard of the whole nervous network. The outline of the brain conforms to the spiral of Archimedes as does the skull. Its shape from above is roughly elliptical with a cleft, or cusp, at either end, looking similar to the meat of a walnut. The investigation of the timing of reflex actions and other responses of the nervous system is recognized as an important unit of mathematical psychology.

Closely associated with the nervous system is the eye. It is nearly spherical in shape, or more accurately, ellipsoidal, with a section of a small sphere merged to the front of it. Light enters the pupil at a speed of 186,000 miles per second and passes through the lens where it is converged, and reproduces the image on the retina which from it is transferred to the brain. The pupil and lens are controlled and focus so that

$$\frac{1}{p}+\frac{1}{q}=\frac{1}{f}$$

where p = the object distance, q = the image distance, and f = the focal length.

Red blood cells are shaped much like a doughnut with the hole thinly filled. They are circular and concave on both sides. This is a definite geometric form.

The heart is a hollow, muscular organ in the thorax, between the lungs, and is shaped something like a blunt cone. Speaking more exactly, the cross section corresponds to the geometric curve known as the cardioid.

There is an interesting curve in the mouth. Hanging from the palate is the soft palate with the conical uvula attached. Viewed from the front these together reveal the graph of a typical fourth power equation. This differs from the equation of the pelvic bone by being inverted.

The pharynx is approximately conical in shape and the esophagus is a cylindrical tube. The trachea is another long cylindrical tube and is non-collapsible because of incomplete rings of cartilage. The trachea divides into two branches and enters the lungs where it divides into smaller tubes.

It is an interesting mathematical fact that so many organs and other parts of the body occur in pairs. Simple mathematics, such as

counting, can be applied to the functions of the organs of the body, for example, taking the pulse or rate of respiration.

The association of mathematics with anatomy and the study of anatomy cannot be denied. Many of the various geometric forms that occur in the human body have been pointed out. Typical physiological processes have been mentioned, some of which are arithmetical and some of which may be represented by formulas.

GEOLOGY INTEREST TESTS FOR HIGH SCHOOL SENIORS

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Despite the fact that there is a recognized shortage of professionally trained geologists, college enrollments in this field are less than the demand in many areas of the United States.

Senior high school graduating classes are usually given a series of orientation or vocational lectures and conferences, so that they may have the utilitarian information at hand to assist them in their choice of a career.

Secondary school counselors, in presenting educational and vocational opportunities to prospective college matriculants, are likely to give but scant attention to some of the lesser known, but worthwhile, vocations.

In Maryland high schools, for example, vocational conferences are scheduled for male juniors and seniors, at which lectures and discussions on standard vocations are presented often by experts in their respective fields. The list of vocations presented apparently varies from year to year but little. Medicine, dentistry, law, pharmacy, clerical, accounting, undertaking, chiropractice, osteopathy, engineering, business administration, transportation, the ministry, teaching, aviation, mechanical and electrical crafts, etc., are the usual topics for urban schools. In rural schools, agriculture, forestry, veterinary medicine, horticulture, etc., are invariably on the list, while mining and metallurgy are stressed in mining regions. The armed services are ready with assemblies in the interests of their respective branches, namely, the army, the air corps, marines, coast guard, and the merchant marine.

The writer prepared a geology and aptitude questionnaire for high school seniors with 331 replies, which were tabulated and evaluated, and which sought to ascertain:

1. Whether or not academic and technical high school seniors have some knowledge of a vocation in geology.

2. Whether or not high school students have had any contact with geology through their science courses.

3. Whether or not high school students have any hobby or avocational aims or interests related to geology.

The questionnaire answers generally indicated: (a) lack of information among high school seniors regarding vocational opportunities in geology except, of course, in mining regions; (b) some latent interest in the subject through knowledge gleaned from the related secondary school sciences in chemistry, biology, physiography, and general science; (c) occasional hobby interest.

Academic and technical students who took the four high school sciences—biology, physics, chemistry, and general science—scored the highest in the questions pertaining to the fundamentals of geology and commercial students made the lowest scores in both aptitude and interest. The college preparatory group, while scoring highest of all the groups tested, still showed a lack of basic knowledge of earth science with mean scores under 50%.

An examination of the modern texts used in high school science showed wide variations in the amount of text material devoted to geology and related topics. High school biology texts varied from 0 to 70 pages, with appropriate tables, charts, photographs, and included diagrams.

Chemistry texts were more consistent with one paragraph on the origin of each mineral, ore, metal, or non-metal studied, including metalurgy and crystallography.

The general science texts varied from 10 to 80 pages. These dealt with geology, erosion, paleontology, physical geography, astronomy, and allied units. Some local high school courses of study, both county and city, omit evolution and paleontology entirely in biology. Formulas, equations, problems, and chemical properties, however, are stressed at the expense of the origin of rocks and minerals in some chemistry courses of study.

One unit of general science is devoted to earth science, but as this is given in the eighth and ninth grades, there is little transfer value to the twelfth grade students.

The vocational possibilities in geology are: (1) geologists in state or federal departments of geology; (2) members of geological survey parties in discovering new mineral resources; (3) geologists in the mining industry; iron, nickel, copper, silver, gold, aluminum, coal etc.; (4) petrographers in metallurgical industries such as steel, copper, and aluminum; (5) geologists in the petroleum industry; (6) prospecting for precious metals and mineral resources; (7) paleontolo-

gists; (8) crystallography; (9) geological testing laboratories; (10) geological cartographers; (11) mineralogists; and (12) research geology.

In addition, opportunities for an interesting and rewarding career exist in teaching the various branches of geology, such as economic, historical, physical, mining (stratigraphy, mineralogy, and crystallography) in colleges and universities. Geologists have an excellent background for teaching the high school sciences: physics, chemistry, biology, and general science. There are prospects for endowed or subsidized fellowships and graduate work in geology.

Recommendations

1. Science research associates might prepare a new up to date vocational brief on "Geology as a Vocation," for use of counselors and vocational guidance directors.
2. That high school vocational counselors add geology to their list of worth-while vocations for presentations to prospective college matriculants.
3. That high school science teachers include geology units in their courses of study, and they should stress the vocational outcomes.
4. The earth science series of film strips and films dealing with erosion, earth science, and soil conversation might be shown to advantage as part of the science audio-visual program.
5. Vocational field trips to local mining, metallurgical plants, oil refineries, and college geology departments might be planned to advantage if feasible.
6. That high school students be encouraged to make rock, fossil, and mineral collections as a hobby or avocation.

GEOLOGY APTITUDE QUESTIONNAIRE FOR HIGH SCHOOL SENIORS

1. Which of these high school sciences have you had, or are taking now? A. Biology; B. Chemistry; C. Shop Science; D. General Science; E. Physics; F. Geography; G. Physiography.
2. If you prefer a traveling occupation, which science would you major in? A. Chemistry; B. Physics; C. Biology; D. Geology; E. Astronomy.
2. If you were interested in mining or mining engineering as a profession, which subject would you consider most valuable? A. Chemistry; B. Geography; C. Geology; D. Archaeology; E. Anthropology.
4. Which vocation do you know least about? A. Medicine; B. Chemical Engineering; C. Pharmacy; D. Geology; E. Accountancy; F. Law.
5. If you had a study choice of topics in biology or general science, which would you place first and second? A. Flowering Plants; B. Forestry; C. Extinct animals such as dinosaurs or mastodons; D. Insects; E. Ancient coal forests; F. Volcanoes and earthquakes; G. Microscopic life.
6. Which history unit would you prefer to study in high school? A. Medieval; B. U. S. Colonial; C. Early European; D. Historical geology (ancient rocks, animals, and plants); E. Archaeology (study of ancient monuments and ruins).

7. If, as a hobby you collected fossils, which subject would you be primarily interested in? A. Paleontology; B. Vertebrate anatomy; C. Anthropology; D. Organic chemistry; E. Physiology.
8. Which would you choose as a collection hobby having a relationship to chemistry (do not answer if uninterested in any of them)? A. Medicinal chemicals; B. Minerals; C. Various grades of lubricating oils; D. Crystals; E. Local rock specimens.
9. Which of these subjects would you define as "earth sciences"? A. Astronomy; B. Mineralogy; C. Physical Geology; D. Oceanography; E. Economic Geography.
10. Which subject would you study if you were employed in making a survey for new oil fields? A. Oceanography; B. Economic Geology; C. Marine Zoology; D. Organic Chemistry.
11. If you expected to join a survey party to find new uranium ore deposits in connection with atomic energy, which college subject would you choose for most helpful information? A. Inorganic Chemistry; B. Physical Geography; C. Geology; D. Soil Conservation.
12. In which rocks are most fossils found? A. Lava; B. Limestone; C. Granite; D. Quartz.
13. What was a dinosaur? A. An ancient reptile; B. Bird; C. Fish; D. Amphibian; E. Mammal.
14. Which is the hardest mineral? A. Talo; B. Galena; C. Quartz; D. Carborundum; E. Graphite.
15. Which is the softest mineral? A. Calcite; B. Mica; C. Marble; D. Garnet; E. Agate.
16. Which one of these statements tend to prove that much of the U. S. was submerged under water during geologic time? A. Wind blown sand; B. Characteristic marine invertebrate fossils; C. Old deltas or river beds; D. Sandstone strata; E. Lava formations.
17. Coal comes from? A. Carboniferous shale; B. Volcanic lava; C. Accumulation of ancient vegetable matter.

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A NEW METHOD FOR FINDING SQUARE ROOT

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PART I—DEVELOPMENT

It is the purpose of this paper to develop and justify the techniques for using a heretofore little known method of finding square roots, and to point out its several advantages over the older and familiar method. The method is adaptable to either the very elementary or the advanced user; to "longhand" or to "machine" operation. Briefly, the method consists of dividing the number whose square root we wish by a guessed value of that square root, then "adjusting" our guess so it is more nearly correct, and repeating the process until the required degree of accuracy is obtained.

First let us develop the underlying principles upon which the method depends. Suppose there is a given number whose square root we require, and suppose we call this required square root "N." Then "N^2" is the given number. Further suppose "g_1" is our first "guess" as to the value of "N," and that "e_1" is the error in this guess. Then $g_1 = N \pm e_1$, where g_1, N, and e_1 are each confined to real, positive quantities other than zero or infinity.* It is unnecessary to consider any other values in finding numerical square root. Our second guess "g_2" will be formed by taking the arithmetical mean of our first guess and the quotient obtained by dividing "N^2" by the first guess. That is,

$$g_2 = \frac{1}{2}\left(g_1 + \frac{N^2}{g_1}\right).$$

Later guesses will be formed in an analogous manner. Thus,

$$g_r = \frac{1}{2}\left(g_{r-1} + \frac{N^2}{g_{r-1}}\right).$$

Now there are three possible cases; our guess is either equal to, greater than, or less than the true value of the root. That is: Case 1 $g_1 = N$; Case 2, $g_1 > N$; Case 3, $g_1 < N$.

Case 1: $g_1 = N$, $e_1 = 0$, our guess is perfect. This is a situation we hope ultimately to reach within limits in Cases 2 and 3 later. Now we divide the number whose square root we wish by our guess. Thus N^2/g_1 becomes $(N^2/N) = N$ with no remainder. The fact that the quotient is identical with the divisor shows us that our guess is correct. So, regardless of what has gone before, when we achieve a

* e_1 may be zero.

situation in which our divisor and quotient are identical for any number of significant figures, we know positively that to this number of significant figures our guess as to the required square root (the divisor) is perfectly correct.

Case 2: $g_1 > N$, so $g_1 = N + e_1$. Thus N^2/g_1 becomes

$$\frac{N^2}{N+e_1} = N - e_1 + \frac{e_1^2}{N+e_1}$$

by long division, and

$$g_2 = \frac{1}{2}\left(N + e_1 + N - e_1 + \frac{e_1^2}{N+e_1}\right) = N + \frac{e_1^2}{2(N+e_1)} \cdot$$

The first guess "g_1" differs from "N" by an amount "e_1," while the second guess "g_2" differs by an amount

$$e_2 = \frac{e_1^2}{2(N+e_1)} \cdot$$

It can be shown that $e_2 < e_1$; that is,

$$\frac{e_1^2}{2(N+e_1)} < e_1.$$

For, upon multiplying both sides by the same real, positive quantity, namely $2(N+e_1)$, we get $e_1^2 < 2Ne_1 + 2e_1^2$, and subtracting e_1^2 from both sides leaves $0 < 2Ne_1 + e_1^2$, which is true by definition of real, positive quantities. It follows then that "g_2" is more nearly equal to "N" than is "g_1." In a similar manner it may be shown that each successive "g" approaches "N" more closely.

Case 3: $g_1 < N$, so that $g_1 = N - e_1$, and remembering that g_1, N, and e_1 are real and positive, $e_1 < N$. Then N^2/g_1 becomes

$$\frac{N^2}{N-e_1} = N + e_1 + \frac{e_1^2}{N-e_1}$$

by long division, and

$$g_2 = \frac{1}{2}\left(N - e_1 + N + e_1 + \frac{e_1^2}{N-e_1}\right) = N + \frac{e_1^2}{2(N-e_1)} \cdot$$

Inspection will show that here "g_2" may be either a better or a worse guess than "g_1." However, since $e_1 < N$, it follows that $[e_1^2/2(N-e_1)]$ is real and positive. That is $g_2 > N$. Therefore, g_3 and all successive guesses are instances of Case 2.

Thus only in Case Three is it possible to make a first guess so wild that the second guess *may* be more in error than the first, but even

though this occurs, all guesses from "g_2" forward will converge toward "N." This possibility is of academic interest only, since any reasonable first guess causes the process to converge immediately. A great deal of the merit of this method lies in the rapidity with which "g" approaches "N."

Part II—Application

Let us now proceed to the practical business of formulating rules and procedures for actually taking the square root of numbers. Although we may put down a set of basic steps in procedure for all to follow, the detailed procedure can and should be different for the elementary student who almost certainly will be working "longhand," and the mathematically mature person who may be using a computer.

Basic Procedure: (New Method).

†1. Proceeding in both directions from the decimal point, mark the digits of the given number, N^2,* off into groups of two.
2. By guess and trial find the number whose *square* is most nearly equal to the left hand group** of the given number, N^2.
3. Divide N^2 by the number found in step 2, carrying the process as far as may be required at any time.
4. Find the arithmetical average between the divisor and the quotient in step 3. This is an approximation to the answer sought and is to be a new divisor to obtain a closer approximation.
5. Using the new divisor of step 4, repeat the processes of steps 3 and 4. Each repetition gives a closer approximation to the answer. Continue in this manner until the answer is as accurate as desired.

Discussion of Procedure Details:

In reference to step 1, note that, relative to the decimal point, there will be a digit in the answer for each group in the given number. For the elementary student the problem of decimal placement may be solved by the arrangement and performance of step 3. See example No. 1.

Note that in step 2, no number greater than 99 ever need be considered. However, more advanced students will often prefer to consider the first two groups as a single quantity, especially when this includes only 3 digits. To do this, however, one should first memorize the squares of all numbers to 32. See example No. 2. Also, whether one takes square roots by this or any other process, it will be an aid to memorize the square roots of the digits from 1 to 10. In any event,

* "N^2" is here the number whose square root is to be taken.

** Two or more groups may be considered simultaneously. See example No. 2.

although it is not necessary to guess a number of more than one digit, it is recommended that one estimate or guess at the second digit of the answer. A trial and error investigation has shown that a completely satisfactory first guess must be within .05 or 5% of the true value. The table below shows the allowable error for several cases.

True answer	10.	4.	2.	1.
Error	.5	.2	.1	.05

As shown in this table the smaller the answer the greater must be the absolute accuracy of our guess. Thus, if it is required to find the square root of 42.5016 a completely satisfactory first guess would be 6.5. This, then should be our first divisor rather than 6.0 or 7.0. However, either of the latter will work! In making the estimate of this second digit one may use in addition to memorized information simple linear interpolation. This is in error by being slightly too small, but is correct to the one digit called for.

In step 3 the only question involved is how far to carry the process. This too will vary somewhat with the mathematical maturity of the user. For the youngest beginner the following is recommended: *CARRY THE FIRST DIVISION TO 3 DIGITS, THE SECOND DIVISION TO 6 DIGITS, AND THEREAFTER TO TWICE AS MANY DIGITS AS SHOW AGREEMENT BETWEEN THE DIVISOR AND QUOTIENT IN THE DIVISION BEING PERFORMED.* See example No. 1. If at the first division at least the first digits do not agree, a very bad guess has been made. One can continue to reapply the process retaining only 3 digits until agreement is reached, or one can start all over again. See example No. 3. If at any time an error is made, it will show up in the next division, or sooner, by the failure of the digits to agree as far as would be expected. In this event the error will be self correcting if we retain only double the number of agreeing digits and proceed to a new division. See example No. 4. If agreement at the conclusion of any division should be worse than on the preceding application, then it is *best,* but not necessary, to repeat the last division process. For the mature user who may be employing a machine, the first "guess" should be correct to 2 or 3 digits, depending on circumstances, and he should retain each time a number of digits that is double +1 the number of agreeing digits between divisor and quotient in that particular division. At this point, attention should be called to situations such as for example $\left|\begin{matrix}6001\\5998\end{matrix}\right|$. At first glance it appears that there is

no digital agreement. Taking the difference we get $\begin{array}{|r|}6001\\5998\\\hline 0003\end{array}$ which shows that they differ by only 3 in the fourth figure. This is equivalent to saying that they do agree in the first *three* places! Had each of these numbers been originally just a little larger or smaller, no confusion would have existed. For example, suppose each had been about three ten thousandths of itself smaller. Then we would have had $\begin{array}{|r|}5999\\5996\end{array}$, and no question would have arisen.

In finding the arithmetical average required in step 4, the beginner may assist himself by a mechanical arrangement shown in illustrative example No. 1. This arrangement not only places the decimal, as mentioned earlier, but makes taking the average practically a write-at-sight process. A mechanical arrangement more suited to the machine operator is shown in example No. 2.

Part III—Comparisons

The following comparisons are made for those people who might wish to consider replacing the old grammar school method of extracting square root by this new method. First, one should compare the Basic Procedures of the two methods. Procedures for the new method have already been stated, page 42, while for those who may have forgotten them, as who hasn't, the steps of the old method are given below as they appear in our better text books.

Basic Procedure: (Old Method)

†Step 1. Proceeding in both directions from the decimal point, mark the digits of the given number, N^2,* off into groups of two;

Step 2. By guess and trial find the largest single digit whose square is equal to or less than the left hand group of N^2. This is the first digit of the answer.

Step 3. Square this number and place the result under left hand group of N^2.

Step 4. Subtract the squared number from the left group.

†Step 5. Bring down the next group from N^2, supplying zeros if necessary.

†Step 6. Consider the last number resulting from step 5 to be a new dividend. Form a trial divisor by multiplying the portion of answer already found by 20.

---

* "N^2" is here the number whose square root is to be taken.

† Steps so marked here and on Basic Procedures of new method, page 42, represent new, and/or unique procedures.

†Step 7. Perform a mental division (as in long division) and place the estimated quotient in two places: as the next digit of the answer, and in place of the final zero of the trial divisor. I.e., add it to the trial divisor.

Step 8. Multiply the complete trial divisor by this last digit of the answer, placing the result under the new dividend.

Step 9. Subtract the product from the dividend as arranged in step 8.

Step 10. If step 9 is impossible because the product is larger than the dividend, as arranged in step 8, then steps 7 and 8 must be repeated using a smaller digit.

Step 11. Repeat steps 5 through 10 in sequence to obtain the third and each succeeding digit of the answer. Carry this process as far as required, obtaining one digit of the answer for each repetition.

Comparison of the Two Methods:

New: Of the five basic steps given, one is a repetition procedure, leaving actually four steps to remember. Only one of these four steps is new in itself, and each is simple. Each reapplication requires two steps, and approximately doubles the number of significant digits we already have. Two applications will give at least four, usually five, and frequently six significant figures. Mistakes are self correcting.

Old: Of the *11* steps given one is a repetition procedure leaving *10* to remember. Of these *10*, *4* are very definitely new ideas, not used elsewhere in mathematics. A reapplication of *6* steps is necessary for each new digit in the answer. Mistakes are not evident, and when found require a complete reworking from their occurrence on.

Part IV—Conclusions

From the foregoing, it would appear that an inescapable conclusion is that the new method is ***far shorter*** and ***simpler*** than the old. This in turn has two important implications. First: the method would be far easier to teach to our grammar school children. Second: once learned, it would be retained much longer.

It should also be remarked with emphasis that, whereas the presently used or old method is useless to the student who later in life may be doing machine computation, the new method suggested here is the best machine method to date.

At present the new method has only been tried on a few students. These, however, have shown excellent results. The author would like to see the method tried out on a group of students in our public schools. A control group employing the older method should of course

be used. General adoption of the method could await the results of such an experiment.

In referring to this paper as "A New Method of Finding Square Root," one must consider the word "new" in a statistical sense. The people who know of the method are few, but the principle is old. The author learned of the basic idea from Dr. D. B. McRae of the U. S. Navy Electronics Laboratory, who in turn had it from Dr. Herzberger of Eastman Kodak.

The author's contributions have been to devise a mechanical system, to formulate general rules and procedures, and in this article to bring the material to the public's attention so that it may be of immediate practical use to a large number of people.

PART V—ILLUSTRATIVE EXAMPLES—See Text

Example No. 1. Problem: Find the square root of 43.2.

Solution: By "Longhand"

```
   6.57 ←—— Average
   6.64 ←—— Quotient
   6.5  ←—— First guess
 √43.2  ←—— The number
   39.0      Division process
    4.20
    3.90
     300
     260
      40
```

....

```
   6.57267 ←—— Average (final ans.)*
   6.57534 ←—— Quotient
   6.57    ←—— Second guess
 √43.20    ←—— The number
   39.42         Division process
    3.780
    3.285
     4950
     4599
      3510
      3285
       2250
       1971
        2790
        2628
         162
```

* Our Answer: 6.57267; Correct answer to 9 places is 6.57267069.

Notes:

The right hand side of the page where these notes are can normally be used for any "scratch work" the student feels desirable.

Note how the mechanical arrangement aids in keeping track of the decimal point. Notice that in the first application of our process (top left) there are two digits in our first guess; the second was obtained by linear interpolation.

Notice also that only *three* digits are retained in the quotient of this first division.

The "*average*" here is an approximation, usually good to two figures (three in this example), to the number sought. It is also our "second guess" in our reapplication (lower left).

In this second application of our process notice the retention of *six* figures in the quotient, and the resultant six figures in our new average. This average is our *answer* to six figures, and could be used in a third application for greater accuracy.

Note that if one had desired only 3, 4, or 5 digits in an answer, this second division could have been terminated at the appropriate place.

Example No. 2. Problem: Find the square root of 741.253.

*Solution: By use of computing machine**

$\sqrt{741.253}$ ←——— Number
27.2 ←——— First guess
27.25194 ←——— First Quotient
27.22597 ←——— First Average and 2nd guess
27.22595374930 ←——— 2nd Quotient
27.22596187465 ←——— 2nd Average and 3rd guess

Notes:

If the work is arranged near the left of the page, the right hand side offers adequate space for any required notes or scribbling.

(Concluded on page 48)

Example No. 3. Problem: Find the square root of 43.2.

Solution: By "Longhand"

6.9
4.8
9. ←— g_1 (First guess)
$\sqrt{43.2}$
36.
7.2
7.2

6.58
6.26
6.9 ←— g_2
$\sqrt{43.2}$
41.4
1.80
1.38
420
414

6.57267 ←— Answer
6.56534
6.58 ←— g_3
$\sqrt{43.20}$
39.48
3.720
3.290
4300
3948
3520
3290
2300
1974
3260
2632

Notes:

It is the purpose of this third example at the left to show what happens if our first guess is very poor to the point of being *stupid*. Let us use the same number, 43.2, taken in example one. As seen there, a "good" guess would be 6.5. A "reasonable" guess for a beginner might be anywhere from 6.3 to 6.7 inclusive. But a guess as unreasonable as say 9 would seem to be "stupid." Note, however, that using this as our first guess, we here required only one short additional step to arrive at the correct answer.

* Any machine is satisfactory that is capable of automatic division and possesses a sufficient number of digital spaces.

In the example on the left hand side of this page, notice the arrangement that keeps track of the decimal point.

The first guess was obtained by considering the first two groups together, i.e. 741. Thus $27^2=729$ and $28^2=784$, then by interpolation we get the .2. This allows us to make an accurate 3 digit guess whereas considering only one group, the 7, would permit us to make only a somewhat less accurate guess at the second digit.

In the first machine operation our quotient and divisor agree to 3 digits so that we retain $2n+1=7$ digits in this division, n being the number of agreeing digits. Similarly in the next division there is agreement to 6 figures, so we retain 13 figures.

Note particularly that only *one* machine operation was here necessary to obtain an answer absolutely correct to 6 figures, and correct to the nearest 7th significant figure. On the average we may expect this sort of accuracy about half the time while on the remaining half our first guess will be good to only two places which means that our first division will retain 5 places of which we are sure of 4. A second division would retain either 9 or 11 places depending on the agreement.

Example No. 4. Problem: Find the square root of 95.7

Solution: By use of computing machine

$\sqrt{95.7}$

$9.6 \longleftarrow g_1$

$9.96 \longleftarrow Q_1$

$\overline{9.83} \longleftarrow g_2$

$9.73 \longleftarrow Q_2$

$\overline{9.78} \longleftarrow g_3$

$9.78527 \longleftarrow Q_3$

$\overline{9.78263} \longleftarrow g_4$

Notes:

In the fourth example at the left a mistake is deliberately made to show the self correcting feature of the process.

In taking the first average to get the value here labeled g_2, an error was made. The 9.83 should have been 9.78. In the next division following the error, it becomes obvious through failure of the digits to agree any better than on the previous trial, that some error has been made, so only three figures are retained again. One additional step, making a total of three machine operations, was all that was here required to correct the error and lead us to the right answer.

Infra-red heat lamp, an industrial 500-watt sealed-beam affair, utilizes a new type of tungsten filament and has the inside of its bulb lined with pure polished silver that acts as a built-in reflector. A protective supporting structure for the filament is a type never before used in heat lamps.

Frostguard, to protect orchards from freezing, is a nickel-alloy kerosene burner and reflector combination, mounted on stilts between the fruit trees. By means of a special generator type burner and a combustion chamber, high heat is developed which is directed downward and outward by the reflector.

THE EXHIBIT AS A SUPPLEMENTARY METHOD

VII. ZODIACUS NOVUS—THE NEW ZODIAC

HAROLD J. ABRAHAMS
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In our century it has become increasingly manifest that the English poet, Alexander Pope, had a capital idea when he wrote the lines which open Epistle II of "An Essay on Man":

> "Know then thyself, presume not God to scan,
> The proper study of mankind is man."

Ours is an era of racial and political tensions. More than ever the schools are called upon, and should feel it their duty, to teach the democratic ideal by every means available, both in subject matter and class-room method. The acceptance of Pope's thesis that "the proper study of mankind is man" can be made a starting point for acquiring knowledge and skill in human relations. Each of the disciplines can make its own peculiar contribution toward the desired goal. The sciences have their own not inconsiderable offering to make upon this high altar. For example a knowledge of the chemistry of the human body is not only of scientific interest and of value in itself from the standpoint of an understanding and practice of the rules of health. Of equal importance is the fact that it can be made an effective point of departure for developing a grasp of the principles underlying democracy. This exhibit attempts to point out that the bodies of men are identical in composition.

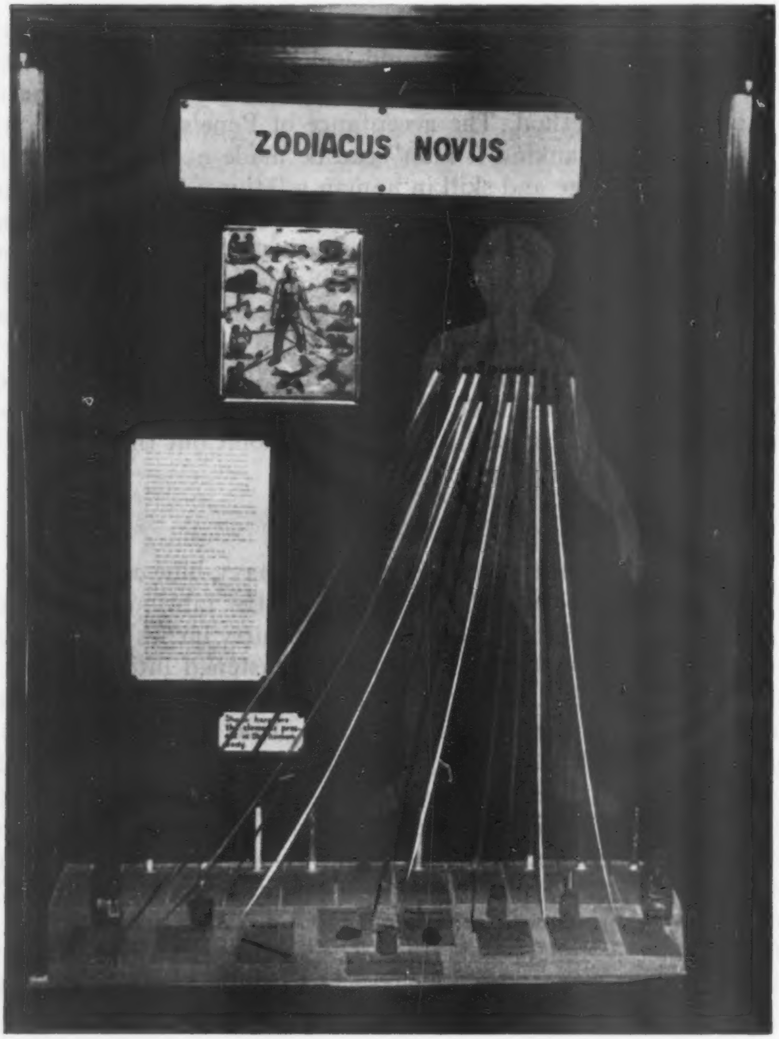
WALL CASE I

The back wall of the case was covered by navy-blue celanese rayon cloth and dark blue thumb-tacks fastened the fabric and all other printed matter in place. A figure of a man, thirty inches high, was cut from plywood by means of a jigsaw and fastened into position, as shown in plate I. From two rows of red thumb-tacks across his chest various colored ribbons lead to specimens of the nineteen elements of the human body. It was found most practical to use as containers, for most of the specimens, a series of four inch test tubes which, filled with the elements, were inverted and cemented to glass microscope slides with "library paste." The legend "Zodiacus Novus" was made from black cut-out letters of one inch height. To the left of the plywood figure there was fastened an eight by ten inch photograph of the signs of the zodiac, made by enlarging the illustration found in an almanac. Below the signs of the zodiac appeared the following plaque:

There was a time, ages ago, when man thought that he could read his fate in the stars. The belief that the heavenly bodies foretold his doom held him in its thraldom for many centuries. Slowly, painfully, with evolving knowledge and unfolding social forms he learned to loosen the grip of these shackles of superstition and to ascribe events both within and without his body to rational causes. Thus there gradually developed many sciences, including those of biology, medicine and, latterly, its triumphant handmaid—chemistry.

Stone by patient stone man erected the edifice of his knowledge of the chemistry of the human body. Slowly man learned, in the words of the "immortal bard" that:

Cassius: Men at some time are the masters of their fates;
The fault, dear Brutus, is not in our stars,
But in ourselves that we are underlings.



Cassius seems to know the influence of diet upon the human body, for he continues, six lines later:

"Now in the name of all the Gods at once,
Upon what meat doth this our Caesar feed,
That he is grown so great?"

Goethe puts it even more clearly, saying "Mann ist was er iszt."—a person is (made up of) what he eats.

Within the last centuries then, man, thanks to chemical science, has come to realize that his body and its parts are not under the influence of the Zodiac and its signs. Superstition has happily been replaced among educated men, by the teachings of a group of medical and kindred sciences, which we might call the "Zodiacus Novus"—the "new zodiac."

And, lest we find ourselves too impressed by our own importance, let us remember that the elements of the body are but given us on loan and that in the end we must return them to the soil and the air, whence they came, when we pass into the "great beyond." "Remember whither thou art going—to a place of dust, worms, and maggots."

Let our origin and our end (from dust to dust) ever remind us of the universality of our chemical composition. To be aware of this fact will help to develop a sense of humility and a healthy perspective, which are the beginnings of all wisdom.

About ten inches above the "floor" of the case appeared the words "Shown here are the elements present in the human body." Below are given the names of the elements which appeared in the exhibit, together with the descriptive data which was typewritten on white cards and fastened over the ends of the ribbons coming from the plywood figure. The ribbons were fastened down with "Scotch tape." It was found desirable to print the name of each element, in large letters, on its card, by hand, to make it stand out.

Back Row

OXYGEN (65%)

Present all through the human body in the form of hundreds of compounds. Oxygen is an invisible gas.

CARBON (18%)

Present all through the body in the form of hundreds of compounds.

HYDROGEN (10%)

Present all through the human body in the form of hundreds of compounds. (One of these compounds is hydrogen oxide or water. Water makes up about 65% of the weight of the human body!) Hydrogen is an invisible gas.

NITROGEN (3%)

Present all through the human body as proteins (muscles, blood, nerves, etc.). The body obtains its nitrogen from plant and animal proteins (lean meat, eggs, cheese, milk, poultry, beans, peas, etc.). In the absence of sufficient nitrogen compounds from the diet a human being would gradually die. Nitrogen is an invisible gas.

CALCIUM (2%)

Present in the bones and teeth as the double carbonate-phosphate $CaCO_3nCa_3(PO_4)_2$. The body obtains its calcium from such foods as milk, cheese, leafy vegetables, cereals, peas, and beans. In America more people are apt to lack calcium than any other element in the diet. Insufficient calcium causes such diseases as bad teeth, rickets, tetany, hemorrhage, etc.

SULPHUR (0.25%)
Widely distributed throughout the human body in proteins, cystine (hair) methionine (muscles) insulin, thiamine (vitamin B_1) melanin (pigment), K_2SO_4, Na_2SO_4, etc. The body obtains its sulphur from onions, garlic, mustard, radishes, turnips, cabbage, meat, and poultry. Insufficient sulphur causes hair and nails to become brittle, a condition which may be cured by eating hulled oats. Red hair has the highest sulphur content.

MAGNESIUM (0.05%)
Present in the body as carbonate and phosphate in the bones and in other compounds in blood, muscles, etc. The human body obtains its magnesium from fruits, vegetables, and meat. Insufficient magnesium may lead to convulsions and to "decalcification" of the skeleton.

COPPER (0.000015%)
Present in the blood in a compound called "hemocuprein," a protein. The body obtains its copper from milk, etc. Insufficient copper interferes with the manufacture of hemoglobin.

IODINE (0.00004%)
Present in the secretion of the thyroid gland as the compound thyroxin. The human body obtains its iodine from river water, fish (haddock and cod especially) and from garlic, onions, radishes, lemons, eggs, milk and butter. Insufficient iodine in childhood causes a form of feeble mindedness called "cretinism" while a shortage in adult life causes "goitre."

FLUORINE
Present in teeth and bones as clacium fluoride, in "trace" amounts. Insufficient fluorine may cause teeth to decay easily. Fluorine is a yellow-green gas. This is not a sample, but a paper representation, because fluorine cannot be stored in ordinary glass. The compound of fluorine and hydrogen (hydrofluoric acid) dissolves glass rapidly and is therefore used for etching upon that substance.

ZINC
Present in insulin of the pancreas in "trace" amounts.

Front Row

PHOSPHORUS (1.1%)
Present in bones, teeth, blood, nerves, muscles. This element is so chemically active, that, unless kept under water, it catches fire. It has been used in one form of incendiary bomb. The body obtains its phosphorus from cheese, nuts, eggs, meat and milk. Insufficient phosphorus causes malnutrition. It is of interest to note that phosphorus is present in the saliva and the tartar which collects on teeth. The body contains enough phosphorus to make 500,000 matches.

POTASSIUM (0.35%)
Present all through the body in the cells and the blood. The body obtains its potassium from vegetables. Potatoes are especially rich in this element. Potassium reacts very violently with water, releasing hydrogen, which catches fire and burns. Magicians sometimes embed a piece of potassium in an icicle and thus make the icicle burn.

COBALT
Present in trace amounts. See "Copper."

SILICON
Present in the eye in "trace" amounts.

MANGANESE (0.00013%)
Present in the blood in the form of a complex protein. The human body obtains its manganese from such foods as lettuce, pineapple, beet tops, and wheat

bran. Insufficient manganese causes failure of red-corpuscle-formation and of general growth.

IRON (0.004%)
Present in the body chiefly as a complex protein known as hemoglobin, the pigment of the red corpuscles of the blood. The human body obtains its iron from lean meat, liver, eggs, oatmeal, raisins, peas, beans and other green vegetables. Whole wheat flour contains much iron, but white flour contains little. Insufficient iron leads to one form of anemia, which can be cured by giving medicines containing iron. The five "tacks" shown here represent the weight of iron present in the human body.

SODIUM (0.15%)
Present all through the human body in the cells and blood as sodium chloride. The body obtains its sodium from the salt used for flavoring food. If insufficient salt is taken in by the body the stomach is deranged, because of the gradual disappearance of hydrochloric acid from the gastric juice. The loss of salt by a heavily perspiring person may produce "heat prostration." Some native tribes punish their prisoners by withholding salt from their diet.

CHLORINE (0.15%)
Present in cells, and blood as sodium chloride and in gastric juice as hydrochloric acid. For details see under "Sodium." Chlorine was used as a poison gas in World War I.

At the very foreground of the case was placed a microscope slide, upon which were etched, by the usual paraffin-hydrofluoric acid method, the words "Central High." The slide was supported by placing it into the groove of a one inch cork, and a card nearby carried the explanation: "The words 'Central High' have been etched with hydrofluoric acid, a compound of fluorine."

Wall Case II

The back of this case was covered with the same kind of cloth as was used in Wall Case I. This case carried the legend "The fault—is not in our stars, but in ourselves—" the purpose being to carry the thread of thought from one part of the exhibit to the other. Beneath the legend appeared a copy of Edgar A. Guest's poem "The Human Body," which seemed appropriate because of both its pointedness and humor.

THE HUMAN BODY*

By Edgar A. Guest

By scientists both wise and old,
  The human body I've been told,
Which weighs about one-forty-five,
  And is what mortals call alive,
Is made of water, nitrogen,
  Carbon, sulphur, iron and then
Potassium, sodium, iodine
  Magnesium, trace of fluorine,
Chlorine, calcium, phosphorus—
  Alike in monarchs as in us.

* "The Human Body" is from the book *Collected Verse of Edgar A. Guest*. copyright 1934 by the Reilly and Lee Co., Chicago.

They've analyzed our flesh and bone,
To them precisely now is known
How much of this, how much of that
Combine to make us lean and fat.
The lovely maiden, fair to see,
Is water mostly, just like me,
Plus so much carbon, iron and all
Those chemicals I won't recall.
'Tis proved this stuff we all possess
No one has more, no one has less.

Well, as they're measured, dump them in
A great retort of glass or tin
And stew them well and stir them round
And see if man you can compound.
I fancy you could mix for weeks
And never get two rosy cheeks,
Or from the batter you prepare,
Produce a maiden young and fair,
Or anything that eats and drinks
Or laughs or sighs or sings or thinks.

I do not doubt this curious list
But think some properties were missed.
To me the human body seems
To be composed of fancies, dreams,
High courage, tenderness, and skill,
Ambition, wisdom, strength of will,
Love, pity, mirth, and all the arts,
And these not given in equal parts.
And thus we differ, you and me,
Who share the self-same chemistry.

This case also displayed the legend "Shown here are some of the compounds present in the human body." Below are given the names of the compounds shown in the exhibit, classified according to locale, together with descriptive data which accompanied them.

SKIN, HAIR, NAILS (Specimens of keratin and cystine)
These contain keratin and cystine.

TEETH (Specimens of calcium phosphate and calcium fluoride)
These are largely calcium phosphate, magnesium phosphate and calcium fluoride.

CARTILAGE (Specimens of gelatin)
This is chiefly collagen, a protein, which on boiling produces gelatin.

VITAMINS
These act as "catalysts." They are not exhibited here, as they are all white powders and show no visible characteristics.

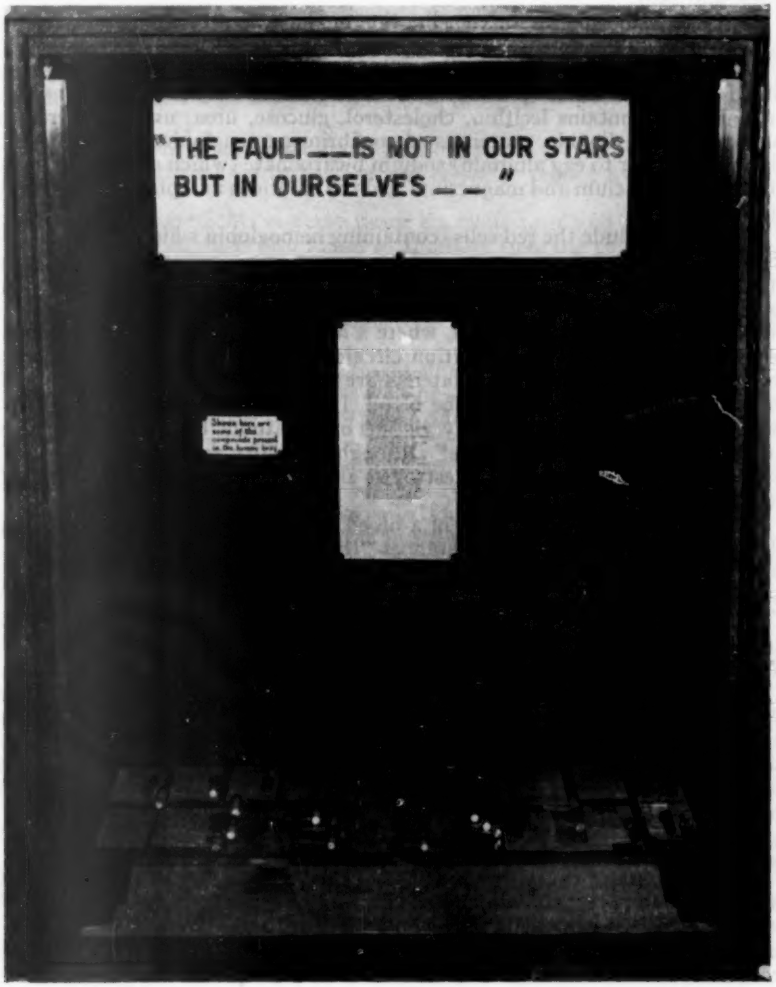
CONNECTIVE TISSUE
This is largely collagen (see "Cartilage"). From this substance attempts have been made to prepare a serum which would postpone the approach of "old age." For a discussion of this subject see the *Scientific American* June 1948, pp. 40–43.

BONES (Specimens of calcium phosphate, magnesium phosphate, calcium carbonate, calcium fluoride)

This is chiefly calcium phosphate, with admixtures of calcium carbonate (limestone), magnesium phosphate, calcium fluoride and collagen (which on boiling changes into gelatin). As a person grows older the collagen is replaced by calcium phosphate and bones therefore break more easily.

MUSCLES (Specimens of taurine, creatinine, glucose, glycogen)

Muscle tissue contains non-nitrogenous and nitrogenous compounds (proteins). Glycogen, lactic acid and fat belong to the first class and creatin, uric acid, myosinogen and paramyosinogen belong to the latter. Sodium, potassium, calcium, magnesium, iron, chlorides and sulphates are also present. ***Chemistry of muscular contraction:*** There are two phases, (a) contractile phase, (b) recovery phase. A. In the contractile phase glycogen is changed into a hexose phosphate (a sugar-like compound) and glucose, then the hexose phosphate changes into lactic acid and a phosphate. B. In the recovery phase the lactic acid and the phosphate change back into the hexose phosphate and glucose, which remakes glycogen. The reason that heat is produced by muscular activity is that some of the glucose produced



is oxidized or burned up. The oxidation or burning is "sparked" by insulin from the pancreas. In the disease called "diabetes" there is little or no insulin in the blood and glucose therefore goes unburned. It finally "spills over" into the urine where its presence indicates the aforementioned disease. *Glycogen* is stored in the liver. It is transformed from insoluble glycogen to soluble glucose when needed by the body and carried by the blood to the working muscle, when it is again converted into glycogen. The working muscle changes it as shown above, into hexose, phosphate, glucose, etc. Glycogen has the same percentage composition as starch and is often called "animal starch." *Lactic acid* is present in sour milk. "Rigor mortis" is due to the accumulation of lactic acid in muscles. *Creatin* is believed to have something to do with muscular contraction.

BLOOD (Specimens of hemoglobin, plasma, urea, glucose)

The blood makes up about 9% of the body weight. It has five chief functions:

1. It carries food from the intestines and oxygen from the lungs to all parts of the body.
2. It carries waste products from all over the body to the kidneys, lungs, intestines, and skin.
3. It carries hormones for coordination of the activities of the body.
4. It helps in the defense of the body against disease.
5. It helps to maintain the "balance" of hydrogen ion, water, and temperature.

Blood consists of fluids (plasma) and solids in about equal proportions by volume. Plasma contains lecithin, cholesterol, glucose, urea, uric acid, creatinine, acetone, carbon dioxide, proteins such as fibrinogen, euglobin, pseudoglobin, and albumin (similar to egg albumin) sodium bicarbonate (which causes it to be alkaline), salts of calcium and magnesium and the chlorides and phosphates of sodium and potassium.

The solids include the red cells (containing hemoglobin which makes them red) the white cells and the "platelets." Hemoglobin is a complex compound consisting of an iron compound called "heme" and a protein called "globin." It has a molecular weight of 66,800! Hemoglobin is the oxygen carrier of the blood. The blood is oxygenated in the lungs, where a loose combination of hemoglobin and oxygen is formed. This combination circulates throughout the body, giving up its oxygen where needed. The platelets are round or oval colorless discs and are associated with coagulation of the blood. Intense radio-activity destroys them. It has been discovered that many victims of the atomic bombings of Japan were found "bleeding from every pore" although no injury was visible. Undoubtedly their blood platelets had been destroyed and the blood just left the body from many places.

Scientists explain the forming of a blood clot in the following manner: In the blood there are present the substances "thromboplastin," "prothrombin," calcium salts and "fibrinogen." When the body sustains an injury and a blood vessel is cut, the "prothrombin" combines with the calcium salts to form "thrombin." The "thrombin" thus formed acts upon the "fibrinogen," forming a new substance called "fibrin," which (because as its name implies, it is fibrinous or fiber-like in character) traps the corpuscles in its net-like structure, forming a clot.

These reactions must not take place in a normal blood vessel, because, if they did, the blood would clot and cause death. This is prevented by the existence in the blood of "anti-thromboplastins," which prevent the thromboplastin from initiating the chain of reactions. Damage to tissue releases an excess of thromboplastin, for which there is insufficient anti-thromboplastin to prevent clotting.

LIVER (Specimens of bile and glycogen)

The bile contains many things—salts of the "bile acids," "bile pigments" (two of the most important of which are "bilirubin," present in lighter colored bile, and "biliverdin," present in green bile), neutral fats, lecithin, cholesterol and salts of iron, copper, calcium, magnesium, and often zinc. Bilirubin contains iron, derived frrom hemoglobin, the iron compound present in the blood.

Bile pigments are converted into a compound called urobiligen in the intestines. This is carried to the liver and enters bile again. If the liver is not in good health, the urobiligen is not removed by the liver, but is excreted in the urine as urobiligen. If urobiligen is excreted it may be a sign of a sick liver.

It has recently been discovered that vitamin B_{12}, which is stored in the liver, is a remedy for pernicious anemia.

DIGESTIVE JUICES (Specimens of pepsin, trypsin and amylopsin)

Digestion takes place in the mouth, stomach, and intestines.

The saliva (mouth) contains the enzyme called "ptyalin" and the compound potassium sulphocyanide. The gastric juice (stomach) contains the enzyme called "pepsin" and the compound hydrochloric acid (0.25%). The intestinal juice (pancreatic juice made by the pancreas) contains trypsin, amylopsin and steapsin. Ptyalin starts the digestion of carbohydrates and amylopsin completes the process. Pepsin starts the digestion of protein and trypsin completes this process. Stepsin digests the fats we eat. Thus these five enzymes digest all three food types—fats, carbohydrates (and sugars) and proteins.

PANCREAS

The pancreas is both an endocrine (ductless) gland and a non-endocrine gland. As a non-endocrine gland it produces pancreatic juice (see "digestive juices"). As an endocrine gland it produces insulin. (See muscles.)

NERVES (Specimens of cholesterol and lecithin)

Nerve tissue contains an amazing amount of water (about 83% in the "gray matter").

Two important ingredients in nerve tissue are cholesterol and lecithin (a phosphorized fat). Cholesterol is also found in the bile. It is the chief ingredient in most gallstones. Lecithin is found in nearly all the tissues of the body.

GLANDS (other than pancreas) (specimens of thyroxine, adrenaline and pituitrin)

The best understood glands at the present time are the "pituitary" at the base of the brain, the thyroid (in the throat) and the adrenal at the top of the kidneys. The pituitary gland produces the substance "pituitrin" which stimulates certain muscles.

The thyroid gland produces the substance "thyroxin" which regulates the speed at which the organs of the body operate. It also aids in the growth of bone. The adrenal gland produces a substance called "adrenalin." This substance causes the blood vessels to become narrow, the heart to beat slower and stronger, the involuntary muscle to contract, the pupil of the eye to widen or dilate and the saliva, tears and bile to flow more freely.

TEST FOR BLOOD (Piece of fabric with blood stain treated as below)

If a blood stain is treated with tincture of guaiac and then hydrogen peroxide, a blue color develops.

It is hoped that such an exhibit may have multiple applications. It is well that teachers of science have always had among their aims, in addition to those set forth above, the clearing away of ignorance, superstition and fatalism so widespread in every area. By reminding our youth of some archaic ideas which once carried authority and, by offering a glimpse of the history of these ideas held by the human race when it was yet young, we may be privileged to make a small contribution to both science and human relations.

THE THEORY OF THE ELECTRON MICROSCOPE

BENJAMIN BOLD
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One of the most recent triumphs of the electron microscope was the observation and photographing of the genes in the chromosomes of the fruit fly. The purpose of this discussion is to indicate how the electron microscope enables one to "see" minute particles that are totally beyond the power of the optical microscope to detect.

The resolving power of a microscope is the measure of its ability to form two separate images of two particles that are very close together. The gene of a fruit fly is approximately 10^{-2} cm. long by 10^{-6} cm. wide, or expressed in terms of Angstrom units, 10^6 A by 10^2 A (since 1 A $=10^{-8}$ cm.). Now, it is not difficult to show that the resolving power of a microscope, or minimum distance between two points of an object that can be distinguished in the image is one-half the wave length (λ) of the light that is used. Consequently, if the wave length of the light used is greater than 200 A, it would be impossible to detect the genes that are present in the chromosomes. Thus the problem is reduced to showing that the wave length of the light used in the optical microscope is greater than 200 A, whereas the wave length associated with a beam of electrons is less than that value.

In order to establish the truth of the last mentioned relation, it is necessary to review a number of the radical changes that have occurred in our understanding of the physical universe since 1900. At that time classical physics conceived the processes of emission and absorption of radiant energy by their ultimate sources (the atoms and molecules comprising the radiant body) as being continuous. As a result of his study of black body radiation, Planck was led to abandon these traditional concepts, and make the bold assumption that an ultimate source does not emit radiant energy continuously, but intermittently in the form of minute parcels or quanta. Furthermore, he assumed that the energy (E) of the radiation was directly proportional to the frequency (ν), the constant of proportionality being h (Planck's constant $=6.63\times10^{-27}$ erg sec.). Thus we have the famous equation of Planck, $E=h\nu$, or $E=h(c/\lambda)$, where c is the velocity of light (3.00×10^{10} cm/sec.), since $c=\nu\lambda$.

The second fundamental departure from classical physics occurred in 1905, when Einstein, as a result of his photoelectric experiments, extended Planck's ideas. Einstein assumed not only that a given source can emit energy only in discrete units of magnitude $h\nu$, but also that the processes of transmission and absorption of energy were likewise restricted to these units, h being a universal constant, char-

acteristic of all radiators and absorbers, whereas ν was a natural characteristic of the radiator or absorber. As a result, we can now conceive of the processes of radiation, transmission, and absorption of radiant energy to be corpuscular in nature. An atom can emit or absorb energy only in the form of discrete units called quanta, or photons, by analogy with the fundamental particles of matter, protons and electrons.

In 1913, a third departure from classical physics occurred, when Bohr formulated a theory to explain the spectrum of atomic hydrogen, wherein he made two assumptions that were in direct contradiction to classical theory. According to classical electrodynamic theory a charged body radiates if and only if its velocity is changing. Bohr postulated that an electron can revolve around its nucleus without radiating. At first, Bohr, for simplicity, assumed the electron to be revolving in a circle which he called a stationary or stable orbit. When an electron in a stable orbit is subjected to a transient disturbance, such as a collision with another electron, photon, or light quantum, the electron may return to its original orbit, pass to another stationary orbit, or be entirely removed from the influence of the nucleus (ionization). The atom would, therefore, radiate or absorb an amount of energy equal to the difference between its final and initial states, the change in energy being $E_2 - E_1 = h\nu$. Furthermore, as a result of investigations of the hydrogen spectrum, Bohr assumed that an electron may revolve in only a limited number of orbits, such that the angular momentum of the revolving electron, $I\omega$, would be an integral multiple, N, of Planck's constant divided by 2π, i.e., $I\omega = N(h/2\pi)$ (N is called the quantum number of the stationary state).

Let us now apply the above theory to the sodium atom. Sodium has an atomic number of 11 and an atomic weight of 23. Its nucleus, therefore, consists of 12 neutrons and 11 protons, and there are 11 planetary electrons, 2 in the first shell, 8 in the second, and 1 in the last shell. The electron in the last shell is called the valence electron. In explaining the sodium spectrum, only changes in the valence electron are considered, the inner electrons merely acting as a shield of the nucleus.

Consider the atoms of a piece of metallic sodium. The valence electrons are revolving in their stationary orbits, and no energy is being absorbed or radiated by the atoms. If, however, the sodium is heated, the atoms will absorb energy, and the electrons will jump to orbits of higher energy states. The atoms remain in the excited state for less than 10^{-6} sec. When the valence electrons return to their normal state, the atoms will radiate energy. The amount of energy absorbed and radiated is given by the formula,

$$E_2 - E_1 = h\nu = \frac{hc}{\lambda}\cdot$$

The wave length of the emitted radiation is inversely proportional to the change in energy. For thermal excitation, this gives a value of $\lambda = 5890$ A (the Fraunhofer D line of the principal series of the sodium spectrum). The resolving power of an optical microscope using yellow light ($\lambda = 5890$ A) would thus be 2945 A. It would be utterly impossible to "see" a gene under such a microscope.

As the intensity of the energy absorbed and emitted by the atoms increases, $E_2 - E_1$ increases, and consequently λ diminishes. The shortest ultra-violet radiation has a wave length of approximately 300 A, so that the gene could not be detected by the ultra-violet microscope.

If the atoms of the metallic sodium were to be excited by collision with a stream of electrons (as the platinum atoms in a roentgen tube), the energy changes would be greater, and the wave length of the emitted radiations smaller, the resulting radiations falling in the range of the X-Ray portion of the electro-magnetic spectrum (from 12 A to 0.1 A).

To understand how the electron microscope can "see" beyond the range of the optical microscope, we need to consider another radical departure from classical physics. This was the entirely new concept of the wave theory of matter introduced into the physical sciences by De Broglie in 1923. According to Planck's equation, the frequency, ν, of a photon is equal to E/h. Also, we know, by Einstein's equation, that E is equivalent to a mass, m, multiplied by the square of the velocity of light, i.e., $E = mc^2$. Substituting the value of E in Planck's equation, we have the following:

$$\nu = \frac{E}{h} = \frac{mc^2}{h}\cdot$$

The wave length, associated with a light quantum is, therefore

$$\lambda = \frac{c}{\nu} = \frac{h}{mc}\cdot$$

Also, we can consider a mass $m = h/\lambda c$ to be associated with a light particle.

If an electron is moving with a velocity, v, by analogy, we can consider that a "matter wave" is associated with this electron, its wave length, λ being, equal to h/mv, h is Planck's constant, m is the rest mass (mo) of an electron, v is its velocity.

The rest mass (mo) of an electron is 9.12×10^{-28} gm. and

$h = 6.63 \times 10^{-27}$ erg sec. A one-volt electron, travelling with a velocity of 5.94×10^{7} cm. per sec., would, therefore, have an associated "matter wave," whose wave length λ, would be

$$\lambda = \frac{h}{mv} = \frac{6.63 \times 10^{-27}}{9.12 \times 10^{-28} \times 5.94 \times 10^{7}} = 1.22 \times 10^{-7} \text{ cm.} = 12.2 \text{ A.}$$

A 100-volt electron would have a velocity of 5.94×10^{8} cm/sec., and λ would be 1.22 A.

Experimental verification of De Broglie's hypothesis was obtained by Davisson and Germer by reflecting electrons from crystal surfaces. The wave lengths thus obtained gave results that agreed excellently with those calculated by the relation $\lambda = h/mv$. Other experimental evidence supporting the wave theory of matter was obtained by G. P. Thomson, who passed high speed electrons through a very thin metal foil, thus obtaining superb Laue diffraction patterns. The results of many other experimenters leave no doubt of the correctness of the wave of matter.

Since the limit of the velocity of a material particle is c, the lowest theoretical value of λ would be

$$\lambda = \frac{h}{mc} = \frac{6.63 \times 10^{-27}}{9.12 \times 10^{-28} \times 3.00 \times 10^{10}} = 2.42 \times 10^{-10} \text{ cm.} = .0242 \text{ A.}$$

Therefore, the highest possible resolving power of the electron microscope would be .0121 A. Operating electron microscopes with resolving powers of 20 A have been constructed. Since the dimensions of the gene of the fruit fly is approximately 1,000,000 A long by 100 A wide, the gene can easily be detected by the electron microscope. There was a lag of more than ten years between the first successful electron microscope and the observation of genes, due to the fact that a new technique was required for obtaining sufficiently thin cross-sectional specimens that would permit electrons to pass through the tissue.

CATHODE RAY TUBE

The cathode ray tube is a bulb of glass that contains a high vacuum. Electrons are shot out by a heated filament at the base of the tube toward an anode. A narrow beam of electrons passes through a small hole in the anode and continues on to the end of the tube which is a screen coated on the inside with a substance which fluoresces (glows) when the electrons strike it.

The cathode ray tube is the heart of your television receiver. In use, the bright spot caused by the stream of electrons sweeps rapidly over the screen while its brightness is controlled to match variations in brightness of the object televised.

Persistence of screen fluorescence plus persistence of vision make you have the illusion of an image on the television screen.

TEACHING AS SALESMANSHIP

Neil E. Stevens
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Twenty-five years after graduation members of the Harvard class of 1911 were asked this question among others, "What professor influenced you most?" Forty-one per cent said "not a doggone one." Sixteen per cent (16%) mentioned Professor George Herbert Palmer, 14% chose former President A. Lawrence Lowell, 13% Professor Frank W. Taussig, 8% Professor Charles T. Copeland.

The foregoing is taken almost in direct quotation from an article by Daniel Starch published in the Iowa Alumni Review of December 1948 and entitled "Is College Worthwhile?" Dr. Starch conducted a study which in some ways resembles that just mentioned. In June 1947 the State University of Iowa celebrated the 100th anniversary of its founding. As a part of the observances, a committee of faculty and alumni had chosen during previous months what they considered the University's most distinguished graduates. Ninety-nine were chosen from among the 40,000 living alumni. To this group of 99 Dr. Starch sent a questionnaire. The general plan was to gain some information on the effect of college training on this group. The second question read, "Did any teachers play an outstanding part in your accomplishments? If 'yes' what about them influenced you most? (Please give names of teachers if you feel free to do so.)" Seventy-two of the 99 to whom the questionnaires were sent, responded. Most of them replied *yes* to the first part of the question just quoted. (Some educationists will be interested to note that slightly less than one-third of these indicated "interest in students" in response to the question, "What about them influenced you most?") According to Dr. Starch's summary almost everyone mentioned one or more teachers by name; however, only five professors were mentioned by as many as five or more of the group. The highest number of references to any one teacher was 11. The figures are matched closely by the replies of the Harvard Class of 1911. The most frequently mentioned Iowa professor was named by 15% as against Harvard's 16% and the next four were named by 8 to 11% as compared with the closely similar figures for the Harvard class.

The close correspondence of these figures from such different sources is at least interesting. The question may then be asked, are they high or low? This can be answered only if a reasonably satisfactory basis of comparison can be found.

Teaching in a present day, liberal arts college is essentially a matter of salesmanship This will, by those familiar with the field, be accepted without question. As far as my own reading goes however no

one except Glenn Frank, once president of the University of Wisconsin and before that editor of the ***Century Magazine***, has used the phrase, "salesmen of knowledge." Even though some courses may be required, the liberal arts teacher still has the basic problem of gaining the interest of his students (one can almost call them prospects), in the face of vigorous competition, not only from teachers of other subjects but still more aggressive promoters of so-called extracurricular activities.

The teacher of botany, for example, who in a required course succeeds in really interesting a student in the alternation of generations has, whether he will admit it or not, shown evidence of very effective salesmanship.

Within the field of commercial selling we have a direct measure of success; that is, a sale actually made. This corresponds roughly to having aroused student interest to such an extent that either the course of the teacher is remembered over a considerable period as having been influential.

I am indebted to my colleague, Dr. Frank Beach, for the following pre-war figures regarding the effectiveness of professional salesmen calling on selected prospects. This group of prospects would be roughly comparable to those students who have been selected for admission to a college in which the number of applicants greatly exceeded those who were admitted.

	Number of Calls	Interviews Granted	Number of Sales
Insurance	10	3	1
Securities	9	3	1
Automobiles	8	3	1

The figures then run from about 10% in case of life insurance salesman to $12\frac{1}{2}$% in automobiles. This would indicate, if the comparison is a fair one, that the four teachers specifically mentioned in the report of the Harvard Class of 1911, and the five Iowa teachers named alphabetically in Dr. Starch's report (Samuel Calvin, Thomas H. Macbride, George T. W. Patrick, Carl E. Seashore, and Samuel Sloan) were indeed salesmen of knowledge of a very high order.

Against these figures each of us can perhaps measure his own success in teaching in a somewhat more tolerant manner.

* * * *

Professor Stevens was born in Portland, Maine April 6, 1887, educated in Portland and in Auburn, Maine. He was a graduate of Bates College in 1908, and took a Ph.D. degree in Botany at Yale in 1911. He taught one year at Kansas State College, then spent 23 years in the Federal Bureau of Plant Industry.

Here he worked on the Chestnut Bark disease, on diseases of small fruits such as strawberry, currant, and cranberry; later on corn diseases, and in the Plant Disease Survey. In 1935 he went to the University of Illinois as professor of botany, and there remained until his death, teaching particularly in the field of plant pathology. His death (June 26, 1949) of coronary thrombosis came after about a year and a half of illness. Hypertension had plagued him for many years.

PRODUCT OF TWO NUMBERS EACH ENDING IN FIVE

J. WM. DREW
Virginia Union University, Richmond 20, Va.

In the general case of the product of two arithmetic numbers ending in five, let us consider each number as having two digits. Let x = the ten's digit in the first and larger number, and since each number must end in 5, 5 will be the unit's digit. In the second number, let y = the ten's digit and 5 its unit's digit.

$10x+5$ = the first number,

and $10y+5$ = the second number.

$(10x+5)(10y+5)=P$, the product of the two numbers.

or $100xy+50x+50y+25=P$.

or $50xy+50x+50xy+50y+25=P$.

$$\frac{100[(xy+x)+(xy+y)]}{2}+25=P$$

or

$$\frac{100[x(y+1)+y(x+1)]}{2}+25=P.$$

The expression

$$\frac{x(y+1)+y(x+1)}{2}$$

is the arithmetic mean between the products of the ten's digit of one number and one plus the ten's digit of the other.

(a) When $x=y$

$$\frac{x(y+1)+y(x+1)}{2} \quad \text{becomes} \quad x(y+1) \text{ or } y(x+1).$$

(b) When $x-y=2$,

$$\frac{x(y+1)+y(x+1)}{2}=\frac{2xy+x+y}{2}$$

and becomes

$$\frac{2y(2+y)+2+y+y}{2}.$$

Note that $2y(2+y)+2+2y$ is divisible by 2, and an integral arithmetic mean is obtainable.

When $x-y=c$, any even positive number, $2xy+x+y$ is divisible by 2, and an integral arithmetic mean is obtainable.

When $x-y=1$,

$$\frac{2xy+x+y}{2}=\frac{2y(1+y)+1+2y}{2}$$

and the mean is (c), $y(1+y)+y+\frac{1}{2}$

(d) This differs from an integral mean by .5.

It can be proved that when $x-y=3$,

(e) the mean is $y(3+y)+y+1\frac{1}{2}$.

When $x-y=k$, any odd positive integral number,

(f) the mean differs from an integral mean by a number equal half of the difference of $x-y$.

This argument provides a short cut for products of pairs of integral numbers ending in 5.

(g) $35\times35=1225$. see (a) above.

(h) $35\times15=525$. See (b) above.

(k) $85\times75=6375$. See (c) and (d) above, and note that the difference of the .5 is added as 50 to the constant 25.

(l) $85\times55=4675$. See (e) above.

(m) $95\times25=2375$. See (f) above.

In squaring a number ending in 5 as in 35×35 in (g), the result may be obtained by multiplying the column of 5's, and bringing down the number 25. Then add 1 to the top 3 and multiply by the 3 in the multiplier.

The result in (h) may be obtained by putting down 25 as in (g) but add 1 to the result obtained by multiplying the subtrahend by 1 plus the minuend which must always be the larger.

The result in (l) is obtained by bringing down the 25 as above, but add $\frac{1}{2}$ the difference between 5 and 8 to the product of the result of the product of the smaller subtrahend and 1 plus the minuend, and increase the 25 to 75.

The argument using a two digit number may be appropriately extended to numbers of more than two digits.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve his readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

Late Solutions

2140–2143. *Bernard Katz, Brooklyn College.*

2146. *Helen M. Scott, Baltimore, Md.*

A Late Solution

2110. *Proposed by Harriet Rathburn, East Springfield, N. Y.*

Solve the system

$$\frac{1}{x^3}+x^2y=486/27$$

$$\frac{1}{y^3}+y^2x=87/8.$$

Solution by Francis L. Miksa, 613 Spring St., Aurora, Ill.

Let $y=Kx$ then the two equations become:

$$1/x^3+Kx^3=486/27=18 \tag{1}$$

$$1/K^3x^3+K^2x^3=87/8. \tag{2}$$

Multiply (1) by K and subtract from (2). Then solve for $1/x^3$

$$\frac{1}{x^3}=\frac{K^3(144K-87)}{8(K^2-1)(K^2+1)}. \tag{3}$$

The value of x^3 found in (3) is now to be substituted in either (1) or (2) giving an equation in K, of the eight degree. Thus.

$$\frac{(144K-87)}{8(K^4-1)}+\frac{8(K^4-1)}{K(144K-87)}=87/8. \tag{4}$$

This becomes, when cleared of fractions,

$$64K^8-12528K^6+7569K^5-128K^4+20736K^3-12528K^2+64=0. \tag{5}$$

Finally when (5) is divided by 64, and all roots multiplied by 4, we get:

$$K^8-3132K^6+7569K^5-512K^4+313776K^3-801792K^2+65536=0. \tag{6}$$

Isolation of the roots of (6) by standard methods reveals four roots. These are given in the following table, together with the values of x and y computed from them:

K	$K/4$	x	y
+ 0.0764867	+ 0.0058502	+6.173452	+0.4721869
+54.69785	+13.67446	+0.3873585	+5.296920
− 0.27106565	+ 0.06776641	−6.428600	+0.4356421
−57.1528087	−14.2882022	+0.3763372	−5.377180

When values of x and y are substituted in equation (1) and (2) they are found to check to seven significant figures.

2155. *Proposed by Francis L. Miksa, Aurora, Ill.*

Show that if two concentric ellipses are tangent to each other, the angle between their major axes is

$$\text{arc tan}\sqrt{\frac{(c^2-a^2)(d^2-b^2)}{(c^2-b^2)(a^2-d^2)}},$$

where a, b and c, d are the semi-axes.

Solution by Alan Wayne, Flushing, N. Y.

Let the ellipses be

$$d^2x^2+c^2y^2=c^2d^2, \tag{1}$$

and

$$(b^2\cos^2\theta+a^2\sin^2\theta)x^2+2(b^2-a^2)xy\sin\theta\cos\theta+(b^2\sin^2\theta+a^2\cos^2\theta)y^2=a^2b^2, \tag{2}$$

so that the angle between their major axes is θ.

At a fixed point (r, s) the equations of the tangents to these ellipses are, respectively,

$$d^2rx+c^2sy=d^2c^2, \tag{3}$$

and

$$(Ar+Bs)x+(Br+Cs)y=a^2b^2, \tag{4}$$

where A, B, and C are the coefficients of the left member of (2). For these tangents to coincide, the corresponding coefficients of (3) and (4) must be proportional, whence, by eliminating r and s, we find that $(a^2b^2-Ac^2)(a^2b^2-Cd^2)=B^2c^2d^2$, so that $a^2b^2+c^2d^2=Ac^2+Cd^2$. By substituting the values of A and C, and expressing $\cos^2\theta$ and $\sin^2\theta$ in terms of $\tan^2\theta$, an expression results which when solved for θ yields the desired result.

A solution was also offered by W. J. Blundon, St. John's, Newfoundland; C. W. Trigg, Los Angeles.

2156. *Proposed by W. R. Talbot, Jefferson City, Mo.*

Find the form of the roots of the cubic equation $f(x)=0$ for which the two areas enclosed by $y=f(x)$ and the x-axis are integers.

Solution by C. W. Trigg, Los Angeles City College

Let the roots of $f(x)=0$ in order of increasing magnitude be r_1, r_2, r_3. We then have to find the areas A_1 and A_2 included between the x-axis and $y=F(x)$

$=a(x-r_1)(x-r_2)(x-r_3)$. When the usual process is employed we find

$$A_1=\int_{r_1}^{r_2} f(x)dx=a(r_2-r_1)^3(2r_3-r_1-r_2)/12=ah^3(h+2k)/12,$$

and

$$A_2=\int_{r}^{r_3} f(x)dx=a(r_3-r_2)^3(2r_1-r_2-r_3)/12=-ak^3(2h+k)/12,$$

where $r_1=r_2-h$ and $r_3=r_2+k$.

Clearly A_1 and A_2 will be integers if h and k are rational and a is divisible by $12d^4$, where d is the L.C.D. of h and k. Or, if we take $a=1$, then h and k must be integers and both must be of the same form, $6m$, $6m+2$ or $6m+4$. In this case, the roots of $f(x)=0$ are either $(b-6p,\ b,\ b+6q)$, $(b-6p-2,\ b,\ b+6q+2)$ or $(b-6p-4,\ b,\ b+6q+4)$ where b is real and p and q are integers.

The proposer also offered a solution.

2157. *Proposed by Olive Ireland, St. Albans, Vt.*

If in triangle ABC, $\angle A=2\angle B$, then show that $a^2=b(c+b)$.

Solution by Margaret F. Willerding, Harris Teachers College, St. Louis, Mo.

In $\triangle ABC$, $\angle A=2\angle B$, hence $\sin A=\sin 2B=2\sin A\cdot\sin B$.

By the law of sines:

$$\frac{a}{b}=\frac{\sin A}{\sin B}=\frac{2\sin B\cos B}{\sin B}=2\cos B. \tag{1}$$

But, by the law of cosines,

$$\cos B=\frac{a^2+c^2-b^2}{2ac}. \tag{2}$$

Substituting (2) in (1), we have

$$\frac{a}{b}=2\left[\frac{a^2+c^2-b^2}{2ac}\right].$$

Solving for a^2 we obtain

$$a^2=b(b+c).$$

the desired result.

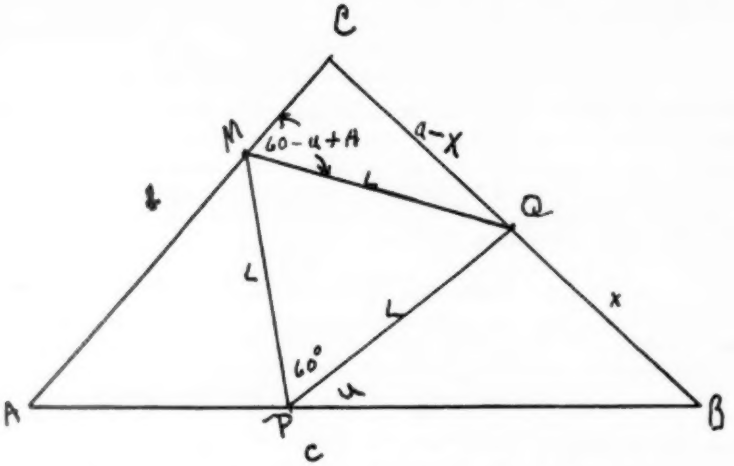
Other solutions were offered by: Helen M. Scott, Baltimore, Md.; Jean Allen, Shelbina, Mo.; Francis L. Miksa, Aurora, Ill.; Margaret Joseph, Milwaukee, Wis.; B. Felix John, Philadelphia, Pa.; Norma Sleight, Winnetka, Ill.; W. J. Blundon, St. John's, Nfld.; Steve R. Domen, Johnstown, Pa.; Gerald Sabin, Tampa University; Alan Wayne, Flushing, N. Y.; Lawrence Levy, Brooklyn, N. Y.; J. Slavin, Brooklyn, N. Y.; C. W. Trigg, Los Angeles City College; and Phillip Zeidenberg, Brooklyn, N. Y.

2158. *Proposed by V. C. Bailey, Evansville, Ind.*

Show that the length of the sides of the least equilateral triangle that can be drawn with its vertices on the sides of a given triangle ABC is . . .

$$\frac{2\sqrt{2}\,\Delta}{\sqrt{a^2+b^2+c^2+4\sqrt{3}\cdot\Delta}}.$$

Where Δ is the area of ABC.



Solution by Francis L. Miksa, 613 Spring St., Aurora, Ill.

Let the vertices of the equilateral triangle be PQM.
Assume angle $QPB=u$ and let $BQ=x$, then $CQ=a-x$.
It is easy to show that the angle $CMQ=(60^\circ+A-u)$.
Using law of sines we write down: (see figure)

$$L/\sin B=x/\sin u \tag{1}$$

$$L/\sin C=(a-x)/\sin(60^\circ+A-u). \tag{2}$$

Eliminating x between (1) and (2) and solving for L we get

$$L=\frac{a\sin B\cdot\sin C}{\sin B\sin(60+A-u)+\sin u\sin C}. \tag{3}$$

Using relation $b/c=\sin B/\sin C$ in (3) we get

$$L=\frac{ac\sin B}{b\sin(60^\circ+A-u)+c\sin u}. \tag{4}$$

Expanding $\sin(60+A-u)$

$$L=\frac{ac\sin B}{b\sin(60^\circ+A)\cos u-b\cos(60^\circ+A)\sin u+c\sin u}. \tag{5}$$

Differentiating with respect to u

$$\frac{DL}{Du}=\frac{-ac\sin B[-b\sin(60^\circ+A)\sin u-b\cos(60^\circ+A)\cos u+c\cos u]}{V^2} \tag{6}$$

where V is the denominator of (5).
Equating $DL/Du=0$ and solving resulting equation, we find

$$\tan u=\frac{c-b\cos(60^\circ+A)}{b\sin(60^\circ+A)}. \tag{7}$$

From (7), using the trigonometric relation

$$1/\cos^2 u=1+\tan^2 u \text{ we get}$$

$$\frac{1}{\cos u}=\frac{\sqrt{b^2+c^2-2bc\cos(60^\circ+A)}}{b\sin(60^\circ+A)}. \tag{8}$$

Now (5) can be written as follows:

$$L=\frac{ac\sin B}{\cos u[b\sin(60°+A)+(c-b\cos\overline{60°+A})\tan u]}. \tag{9}$$

Substituting value of $\tan u$, and $\cos u$ from (7) and (8) in (9) and simplifying we get:

$$L=\frac{ac\sin B}{\sqrt{b^2+c^2-2bc\cos(60°+A)}}. \tag{10}$$

The value under the radical becomes

$$b^2+c^2-2bc\left(\frac{\cos A}{2}-\sqrt{3}\cdot\frac{\sin A}{2}\right). \tag{11}$$

But

$$\cos A=\frac{b^2+c^2-a^2}{2bc} \quad \text{and} \quad \sin A=\frac{2\triangle}{bc} \tag{12}$$

so that (11) becomes

$$\frac{a^2+b^2+c^2+4\sqrt{3}\,\triangle}{2}. \tag{13}$$

Putting (13) in (10) and remembering that $a\cdot c\cdot\sin B=2\Delta$ we get

$$L=\frac{2\sqrt{2}\cdot\triangle}{\sqrt{a^2+b^2+c^2+4\sqrt{3}\cdot\triangle}}.$$

A solution was also offered by W. J. Blundon, St. John's, Newfoundland.

2159. *Proposed by C. W. Trigg, Los Angeles City College.*

If $f(x)=x^3+10x^2+mx-12=0$ and $g(x)=x^3+2x^2+nx+2=0$, have two roots in common, solve each equation completely.

Solution by M. M. Dreiling, St. Joseph's College, Collegeville, Ind.

$$f(x)=x^3+10x^2+mx-12=0$$
$$g(x)=x^3+2x^2+nx+2=0.$$

Let the roots of $f(x)=0$ be a, b, c and of $g(x)=0$ be a, b, d. Then

(1)	$a+b+c=-10$	(1)′	$a+b+cd-=2$
(2)	$ab+ac+bc=m$	(2)′	$ab+ad+bd=n$
(3)	$abc=12$	(3)′	$abd=-2$

(3) and (3)′ yield $d=-c/6$.

From (1) we have $a+b=-(10+c)$. Substituting the values of d and $(a+b)$ in (1)′ yields $c=-48/7$. $\therefore d=8/7$.

(3) also yields $ab=12/c$. Substituting the values of ab, $(a+b)$, and c in (2) gives $m=3881/196$, while the substitution of the values of ab, $(a+b)$, and d in (2)′ gives $n=-1047/196$. Now the substitution of the value of b from (1) in (1)′ leads to the quadratic $28a^2+88a-49=0$. Hence

$$a=\frac{-22\pm\sqrt{827}}{14}$$

$\therefore$ roots of $f(x)=0$ are

$$\frac{-22\pm\sqrt{827}}{14}, \quad \frac{-22-\sqrt{827}}{14}, \quad -48/7,$$

and of $g(x)=0$ are

$$\frac{-22+\sqrt{827}}{14}, \quad \frac{-22-\sqrt{827}}{14}, \quad 8/7.$$

Other solutions offered by: W. J. Blundon, St. John's, Nfld.; Margaret Joseph, Milwaukee, Wis.; Norma Sleight, Winnetka, Ill.; Lawrence Levy, Brooklyn, N. Y.; Steve R. Domen, Johnstown, Pa.; Hazel S. Wilson, Annapolis, Md.; Phillip Zeidenberg, Brooklyn, N. Y.; Helen M. Scott, Baltimore, Md.; and the proposer.

2160. *Proposed by W. H. Cleveland, Meridian, Miss.*

Three bells commenced to toll at the same time, and tolled at intervals of 23, 29 and 34 seconds, respectively. The second and third bells tolled 39 and 40 seconds, respectively, longer than the first. How many times did each bell toll if they ceased in less than 20 minutes?

Solution by C. W. Trigg, Los Angeles City College

Let x, y and z be the times tolled by the first, second and third bells, respectively. Then the respective periods of tolling were $23(x-1)$, $29(y-1)$ and $34(z-1)$, all of which are less than 1200. Hence $x<54$.

Now $23(x-1)+39=29(y-1)$, so $y=(23x+45)/29$. The first three solutions of this indeterminate equation are $(x, y)=(22, 19), (51, 42), (80, 65)$.

Also $23(x-1)+40=34(z-1)$, whereupon $z=(23x+51)/34$. The first three solutions of this equation are $(x, z)=(17, 13), (51, 36), (85, 59)$.

It follows that the first bell tolled 51 times, the second 42 times and the third 36 times; the elapsed periods being 1150, 1189 and 1190 seconds, respectively.

Other solutions offered by: C. E. Estherhammer, St. Joseph's College, Collegeville, Ind.; M. M. Dreiling, Collegeville, Ind.; Jean Allen, Shelbina, Mo.; Francis L. Miksa, Aurora, Ill.; Betty Swanson, Chicago, Ill.; W. J. Blundon, St. Johns Nfld.; and the proposer.

HIGH SCHOOL HONOR ROLL

The editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

2157. *James Kiefer, Olivia, Minn.*

2157, 60. *Jean Allen, Shelbina, Mo.*

2157, 9. *Richard Schubert, Cicero, Ill.*

PROBLEMS FOR SOLUTION

2173. *Proposed by C. W. Trigg, Los Angeles City College.*

Evaluate

$$\sum_{n=0}^{\infty} \frac{(2n+1)!}{2^{3n}(n!)^2}.$$

2174. *Proposed by W. R. Talbot, Jefferson City, Mo.*

Solve for x:

$$4RSx^3-2S\left(\frac{1}{\sin A}+\frac{1}{\sin B}+\frac{1}{\sin C}\right)x^2+2\,px-1=0$$

where

$$\frac{S}{p}=4R\sin\frac{A}{2}\sin\frac{B}{2}\sin\frac{C}{2}.$$

2175. *Proposed by Milton D. Eulenberg, Chicago.*

Find the side of a square, given that from a point within the square the distances to three vertices taken in order are 3, 4, and 5.

2176. *Proposed by Daisy Coryell, Edmonton, Canada.*

Show that the system of equations has no solution:

$$yx^2-(y^2-3y-1)x+y=0$$
$$x^2-y^2+3=0.$$

2177. *Proposed by Norman Anning, University of Mich.*

In a triangle with sides x, $x+2$, $x+4$, if the angles are to be acute, what restrictions must be placed upon x?

2178. *Proposed by V. C. Bailey, Evansville, Ind.*

A tower 51 feet high has a mark at a height of 25 feet from the ground; find at what distance the two parts subtend equal angles to an eye at the height of 5 feet from the ground.

BOOKS RECEIVED

Living Chemistry, by Maurice R. Ahrens, *Assistant Superintendent and Director of Instruction, Battle Creek Public Schools, Battle Creek, Colo.;* Norris F. Bush, *Principal, Evans School, Denver, Colo.;* and Ray K. Easley, *Tecaher of Chemistry, East High School, Denver, Colo.* Revised Edition. Cloth. Pages iv+551+xxxii. 21×25.5 cm. 1949. Ginn and Company, Statler Building, Boston 17, Mass. Price $3.60.

The Business Helper, by Leslie C. Rucker. Cloth. 133 pages. 12×18.5 cm. 1949. John F. Rider, Publisher, Inc., 480 Canal Street, New York 13, N. Y. Price $2.00.

Progressive Problems in Physics, by Fred R. Miller, *Formerly Head of the Department of Science, The English High School, Boston, Mass.* Sixth Edition. Cloth. Pages vii+237. 12.5×18.5 cm. 1949. D. C. Heath and Company, 285 Columbus Avenue, Boston 16, Mass. Price $2.00.

Human Growth. The Story of How Life Begins and Goes On. Based on the Educational Film of the Same Title, by Lester F. Beck, Ph.D. *Associate Professor of Psychology, University of Oregon.* Cloth. 124 pages. 13×20 cm. 1949. Harcourt, Brace and Company, 383 Madison Avenue, New York 17, N. Y. Price $2.00.

Philosophy of Nature, by Moritz Schlick. Translated by Amethe von Zeppelin. Cloth. Pages xi+136. 14×21.5 cm. 1949. The Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $3.00.

Laboratory Experiments in Organic Chemistry, by Roger Adams, *Professor of Organic Chemistry in the University of Illinois,* and John R. Johnson, *Professor of Organic Chemistry in Cornell University.* Fourth Edition. Cloth. Pages xiv+525. 14×21 cm. 1949. The Macmillan Company, 60 Fifth Avenue, New York, N. Y.

Saturating Core Devices, by Leonard R. Crow, *Director of Research and Development of the Universal Scientific Company, Inc.* Cloth. Pages xiv+373.

13.5×21.5 cm. 1949. The Scientific Book Company, 530 South 4th Street, Vincennes, Ind. Price $4.20.

LEARNING ELECTRICITY AND ELECTRONICS EXPERIMENTALLY, by Leonard R. Crow, *Director of Research and Development, Universal Scientific Company, Inc.* Cloth. Pages xi+525. 13.5×21.5 cm. 1949. The Scientific Book Company, 530 South 4th Street, Vincennes, Ind. Price $4.40.

AN EXPERIMENTAL STUDY OF TWO METHODS OF LONG DIVISION, by Kenneth Gary Fuller, Ph.D. *Teachers College, Columbia University.* Contributions to Education, No. 951. Cloth. 76 pages. 15×23 cm. 1949. Price $2.10.

ANALYTIC GEOMETRY, by Lyman M. Kells, *Professor of Mathematics, United States Naval Academy*, and Herman C. Stotz, *Associate Professor of Mathematics, United States Naval Academy.* Cloth. Pages viii+280. 15×23 cm. 1949. Prentice-Hall, Inc., 70 Fifth Avenue, New York 11, N. Y. Price $2.85.

THE CRAFT OF CERAMICS, by Geza deVegh and Alber Mandi. Cloth. Pages xii+145. 18.5×25.5 cm. 1949. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York 3, N. Y. Price $3.80.

MAN AND THIS MYSTERIOUS UNIVERSE, by Brynjolf Bjorset. Cloth. Pages viii+174. 13.5×21.5 cm. 1949. The Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $3.75.

WEBS IN THE WIND, by Winifred Duncan. Cloth. Pages xv+387. 18.5×25.5 cm. 1949. The Ronald Press Company, 15 East 26th Street, New York 10, N. Y. Price $4.50.

PRACTICAL MATHEMATICS, PART I, ARITHMETIC WITH APPLICATIONS, by Claude Irwin Palmer, *Late Professor of Mathematics and Dean of Students, Armour Institute of Technology*, and Samuel Fletcher Bibb, *Associate Professor of Mathematics, Illinois Institute of Technology, Armour College of Engineering.* Fifth Edition. Cloth. Pages xii+179. 13.5×20.5 cm. 1949. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York 18, N. Y. Price $1.80.

THE NATURE OF PHYSICAL THEORY, by P. W. Bridgman, *Hollis Professor of Mathematics and Natural Philosophy, Harvard University.* Cloth. 138 pages. 13.5×20.5 cm. 1936. Dover Publications, Inc., 1780 Broadway, New York 19, N. Y. Price $2.25.

THE THEORY OF GROUPS AND QUANTUM MECHANICS, by Hermann Weyl, *Professor of Mathematics in the University of Göttingen.* Translated from the Second (Revised) German Edition by H. P. Robertson, Associate Professor of Mathematical Physics in Princeton University. Cloth. Pages xxii+422. 13.5×20.5 cm. Dover Publications, Inc., 1780 Broadway, New York 19, N. Y. Price $4.50.

THE PHYSICAL PRINCIPLES OF THE QUANTUM THEORY, by Werner Heisenberg, *Professor of Physics, University of Leipzig.* Translated into English by Carl Eckart and Frank C. Hoyt, *Department of Physics, University of Chicago.* Cloth. 184 pages. 13.5×20.5 cm. 1930. Dover Publications, Inc., 1780 Broadway, New York 19, N. Y. Price $2.50.

AN INTRODUCTION TO THE MECHANICS OF VISCOUS FLOW, by H. F. P. Purday, B.Sc., A.C.G.I., A.M.I. Mech. E. *Chief Designer in the Higher Speed Diesel Engine, Department of Harland and Wolff Limited.* Cloth. 185 pages. 13.5×20.5 cm. 1949. Dover Publications, Inc., 1780 Broadway, New York 19, N. Y. Price $2.75.

PRINCIPLES OF A NEW ENERGY MECHANICS, by Dr. Jakob Mandelker, *Assistant Professor of Mechanics, Georgia Institute of Technology, Atlanta, Georgia.* Cloth. Pages viii+73. 14.5×23.5 cm. 1949. Philosophical Library, 15 E. 40th Street, New York 16, N. Y. Price $3.75.

BOOK REVIEWS

JAMES WATT AND THE HISTORY OF STEAM POWER, by Ivor B. Hart, *Author of The Mechanical Investigations of Leonardo da Vinci, Makers of Science, The Great Physicists, The Great Engineers, etc.* Cloth. Pages xii+250. 13.5×21 cm. 1949. Henry Schuman, Inc., 20 East 70th Street, New York 21, N. Y. Price $4.00.

It is difficult for us to picture a world without steam power—a manufacturing country in which most of the manufactured products were produced, one piece at a time, in the homes and the pieces finally assembled in a central plant. Today we often think of electricity being the motive force until we ask the source of the electric power and trace it to a giant steam engine or turbine which drives the mighty generator. This book is a history of the development of steam power. The first half tells of the thoughts and attempts, with a degree of success, of such men as Da Vinci, Della Porta, Somerset, Huyghens, Savery, Papin, and finally Thomas Newcomen, who produced the steam-driven water pumps for draining the mines so metals and coal could be brought to the surface, for turning swamp lands into cultivated areas, and for furnishing the cities with water supplies. Newcomen died suddenly in 1729. His work was taken over and improved upon by others among whom was Smeaton, who produced an engine for lifting water with nearly double the efficiency of Newcomen's engines. James Watt was born in 1736, but according to Dr. Hart's account did not begin his study of the steam engine until he was about twenty-three years of age. Hence according to this author the stories and pictures of a little child focusing attention on a boiling teakettle of water are probably just as mythical as many other hero stories. The last half of the book tells the real story of Watt's life and struggle in perfecting the engine and its adoption by all the great manufacturing firms of Great Britain. It is an excellent book for young and old, and a worthy companion of *The Great Physicists* and *The Great Engineers*, previously written by the same author.

G. W. W.

INSTALLATION AND SERVICING OF LOW POWER PUBLIC ADDRESS SYSTEMS, by John F. Rider. Cloth. Pages iv+204. 13.5×19 cm. 1948. John F. Rider Publisher, Inc., 480 Canal Street, New York 13, N. Y. Price $1.89.

This is a book for the practical man who has the enterprise and ambition to work up an excellent business for himself and be of real service to the public. In general only low-power apparatus is discussed but when this is thoroughly understood, it is easy to expand because much of the high-power equipment is the same or very similar. The book starts with an excellent chapter on the fundamentals of sound, with emphasis on the hearing apparatus and its sensitivity. The following four chapters, Microphones and Phonograph Pickups, Impedance Matching, Amplifier Specifications, and Loudspeakers cover the theory needed. Chapter 6 on Installation gives the practical work on the location of microphones and loudspeakers in auditoriums, restaurants, night clubs, churches, athletic fields, parks, etc., and mobile P-A systems. The final chapter on Servicing gives equipment needed and brief but reliable methods for locating sources of trouble and making the necessary repairs and replacements. The language is clear throughout and a limited number of excellent diagrams assist the student to master the details.

G. W. W.

A SHORT COURSE IN DIFFERENTIAL EQUATIONS, by Earl D. Rainville, *Associate Professor of Mathematics, The University of Michigan.* Cloth, pages ix+210. 14×21 cm. 1949. The Macmillan Company, New York. Price $3.00.

As the title indicates, this text is planned for a brief course. Most of the material found in a first course is included, however certain topics frequently found among the contents of an elementary text are omitted, i.e., partial differential

equations, series solutions, approximation methods, series solutions. The text seems exceptionally well written, in particular one might comment favorably upon the discussion of the choice of the form in which a solution is written; likewise the care with which the author points out the need for rigorous proof of certain statements (and gives reference to which the reader may turn for such proof).

There seems to be an ample supply of problems, with answers supplied for the majority of such problems. There is a brief chapter explaining hyperbolic functions, appearing before any use of these functions is made in the text.

Some teachers may object to the order of presentation in which 133 pages are devoted to discussion of various methods of solution, with many exercises, but with almost no applied problems. The applications are very largely concerned with problems of electric circuits and of vibrating strings—the author states that he thinks the student will benefit more from detailed study of these two applications than from casual contact with various applications.

That the author has a sense of humor is indicated by the footnote on page 113.

CECIL B. READ
University of Wichita

THE CONCEPTS OF THE CALCULUS, A CRITICAL AND HISTORICAL DISCUSSION OF THE DERIVATIVE AND THE INTEGRAL, by Carl B. Boyer, *Associate Professor of Mathematics, Brooklyn College.* Pages vi+346. 16.5×23.5 cm. Cloth. Hafner Publishing Company, Inc., 31 E. 10th St., New York 3, N. Y. Price $5.50.

The original edition of this book was reviewed in SCHOOL SCIENCE AND MATHEMATICS for December, 1939. The book has been out of print for several years; since this is a new printing rather than a new edition the changes are minor. Comments made in the original review ten years ago are still valid. The book, practically impossible to obtain in recent years, is not only a valuable reference for the calculus teacher but it also contains much of value for the teacher of more elementary subjects.

CECIL B. READ

ELEMENTARY MATHEMATICS FROM AN ADVANCED STANDPOINT. GEOMETRY. Felix Klein. Translated from the third German edition by E. R. Hedrick, *Vice President and Provost, The University of California* and C. A. Noble, *Professor of Mathematics, Emeritus, The University of California.* Cloth. Pages ix+214. 14.5×22 cm. Copyright 1939. Dover Publications, Inc., 1780 Broadway, New York 19, N. Y. Price $2.95.

This is a reproduction (including even some typographical errors) of a book originally published about a decade ago, and which was reviewed in SCHOOL SCIENCE AND MATHEMATICS, Volume 40, pp. 399–400. The reviewer sees no reason to alter the comments which were made there; the present publisher seems to feel that review of sufficient importance to quote a portion of it on the book jacket; it would seem that interested readers might refer to the previous review.

CECIL B. READ

FUNDAMENTALS OF SYMBOLIC LOGIC, by Alice Ambrose and Morris Lazerowitz *Associate Professors of Philosophy, Smith College.* Cloth. Pages ix+310. 15×22 cm. 1948. Rinehart and Company, Inc., New York, N. Y. Price $5.00.

Although the authors state that this book is planned for the intelligent general reader as well as for the student in the classroom, it is doubtful that it will make any "best-seller" lists. The book would, however, seem well adapted for use as a text in a first course. At the conclusion of each of the twelve chapters there is a list of questions and exercises designed to test the grasp of the material.

The order of presentation of material differs considerably from some texts; for example the topic of syllogisms appears late in the book, the concept of classes and their diagrammatic representation does not appear until the tenth chapter.

Nevertheless the authors have very successfully shown how it is possible to build a system resting upon a few relatively simple concepts.

The purpose of the book is to form an introduction to the subject and give a basis for advanced work in the field yet at the same time provide some help in the application of formal logic to reasoning. Some idea of the scope of the material covered may be given by listing certain topics selected somewhat at random: symbolic and classical logic; interdefinability of the logical constants; the DeMorgan theorems; syntactical rules; matrix analyses; the four Aristotelian forms; Venn diagrams; antilogisms; the calculus of classes.

There is a rather complete index; it might have been of value to include a list of symbols used since without such a list some little searching may be required to find the meaning of a symbol unfamiliar to the casual reader (as contrasted with one who reads the book from start to finish). Certainly the book should receive careful consideration when seeking a text for a first course in symbolic logic.

CECIL B. READ

ANALYTIC GEOMETRY, THIRD EDITION, by W. A. Wilson, *Late Professor of Mathematics, Yale University*, and J. I. Tracey, *Associate Professor of Mathematics, Yale University*. Cloth. Pages x+318. 15.5×22.5 cm. D. C. Heath and Co., Boston. Price $2.75.

The textual material of this edition varies very little from the "Alternate Edition" of 1937, which in turn is much like the edition of 1925. The third edition has been completely reset with many new diagrams. These are not always an improvement, in some cases the scale has been omitted, and in many instances the new arrangement is such that the explanation and diagram are now on opposite sides of the page. Some new problems have been added, many of the numerical examples have been changed, but by no means all. If one of the purposes of a new edition is to provide new drill exercises in place of those now in fraternity files, this revision is not entirely satisfactory; there is no excuse, for example, in not changing literal constants in such examples as 16, 21, and 22 in section 5. The illustrative examples are, with a very few exceptions, identical with those of the last edition. In a few instances additional applications have been given—for example the application of the hyperbola to Loran in navigation. In common with many texts, it is not pointed out that tests for symmetry given for use with polar coordinates provide sufficient but not necessary conditions.

The third edition has an index, an unfortunate omission in the previous edition. Answers are included for the majority of the odd numbered problems, and are available in a separate pamphlet for even numbered problems.

CECIL B. READ

ANALYTIC GEOMETRY AND CALCULUS, A UNIFIED TREATMENT, by Frederic H. Miller, *Professor of Mathematics, The Cooper Union School of Engineering*. Cloth. Pages xii+658. 15×22 cm. 1949. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y. Price $5.00.

This text is obviously designed for the course covering both subject fields. In spite of the attempt at a unified treatment, there are spots in which one wonders if traditional material of the course in analytics has not been retained for the mere sake of tradition—the only change being in the method of treatment (an example would be the section on tangents to conics).

Some features of the text were exceptionally pleasing: the treatment of maxima and minima is unusually well done; the section on intersection of loci in polar coordinates is better than one usually finds, as is also true regarding the material on finding the area of polar curves by integration; the examples seem sufficient in number and seem well selected. On the other hand, certain topics found less favorable reception: in the graphs of curves involving trigonometric functions a different scale is used on the two axes (approximately π on the one axis is equal

to unity on the other); according to the definition of an asymptote on page 12 the X-axis is not an asymptote of the curve $y=e^{-x}\sin x$; in the discussion of parametric equations it is not pointed out that a parameter may be selected such that the resulting equations give only a portion of the curve defined by the original rectangular equation; in the discussion of symmetry in polar coordinates it is not pointed out that the conditions given are sufficient but not necessary; the orientation of axes used in three dimensional space seems unusual.

Obviously opinions as to the merits of a text will differ—there are relatively few texts available for a unified course and if a text for such a course is desired, this book should be given very careful consideration. It would not seem feasible to attempt its use in two separate courses.

CECIL B. READ

CALCULUS, by Lloyd Smail, Ph.D., *Professor of Mathematics at Lehigh University*. Cloth. Pages xiii+592. 15×22 cm. 1949. Appleton-Century-Crofts, Inc. New York, N. Y. Price $4.50.

This would be classified as a standard text in first year calculus; it follows the currently popular practice of the introduction of integration following the differentiation of algebraic functions. More topics are considered than would probably be included in most courses, but the text is so arranged that considerable selection of material can be made without destroying continuity. Illustrative of more detailed treatment than is often encountered might be cited the discussion of hyperbolic functions, simple harmonic motion, multiple roots of polynomial equations, and the directional derivative. On the other hand, some teachers might prefer that the author give a more detailed treatment of the limit e, rather than refer to "more advanced works." It should be noted that without exception, where such a statement is made, the author is careful to give at least one reference to such advanced work with page citation.

In order to simplify the statement of many results, the author introduces the concept of a *smooth* function (a function such that both the function and its first derivative are continuous); whether the advantage gained offsets the fact that this is not a term usually encountered in elementary texts is debatable.

Features which seemed of distinct value include the chapter on Taylor's formula with a remainder, which precedes the treatment of infinite series; the substitution of a theorem by Bliss for Duhamel's theorem; the careful distinction between iterated and multiple integrals. On the other hand, certain items seem to detract from the general excellence of the text: the definition of integral calculus in the first paragraph seems unnecessarily restrictive (. . . concerned with . . . finding a function when its rate of change is given); in the application of Newton's method, one wonders how close is *sufficiently close* (p. 101); on page 134 the evaluation of the integral $\int_0^a \sqrt{a^2-x^2}\,dx$ by use of an elementary geometry result seems artificial; the graphs of the sine and cosine curves on page 188 are poorly drawn; no mention is made of alternative definitions of the principal values of the inverse trigonometric functions; in the discussion of the damped vibration curve the student might well ask how it is known that maximum and minimum points are to the left of the points of contact with the boundary curves.

There is an ample supply of exercises, with answers provided to the odd numbered problems. An appendix contains the usual formulas for reference from algebra, trigonometry, and analytical geometry; numerical tables include a four place table of natural functions tabulated at intervals of 0.01 radian; exponential and hyperbolic functions; natural logarithms (to five significant figures, at intervals of 0.01 from 1.00 to 9.99); and a table of squares, square roots, cubes, and cube roots from 1–100. The typography is good, no misprints being noted; the book does, however, present a somewhat crowded appearance on many pages.

CECIL B. READ

SLOBIN AND WILBUR'S FRESHMAN MATHEMATICS, THIRD EDITION, revised by C. V. Newsom, *Assistant Commissioner for Higher Education, The State of New*

York, Formerly Professor of Mathematics, Oberlin College. Cloth. Pages xiv +559. 16×23.5 cm. 1949. Rinehart and Company, Inc., New York, N. Y. Price $5.00.

Many teachers have voiced an objection to certain texts in first year college mathematics in that they include selected portions of material through integral calculus, yet omit important topics in algebra, trigonometry, or analytics—the objection gains importance when in a university some transfer students come from schools using such a text and others from schools teaching the "standard" courses. This criticism would not seem to be valid with respect to this book. The aim is definitely to present the material of college algebra, trigonometry, and analytic geometry, in one text, without going beyond these subjects. Enough material is presented to keep a good class busy a whole year; certain topics could be omitted, but in general the sequence of the three subjects should be that just mentioned. The treatment would be definitely classified as traditional, although current trends in course content have been recognized. (For example, this revision eliminates the discussion of infinite series, but includes material on inequalities; additional emphasis on analytic trigonometry is mentioned in the preface; the treatment of curve fitting is exceptionally well done.) In trigonometry, the general angle is introduced first, and the acute angle considered as a special case; in analytic geometry, polar coordinates occur throughout the treatment and not in an isolated chapter.

Certain material, perhaps in some cases of minor importance, might be criticized: in defining the laws of exponents the restriction that the base must not be zero in defining $a^m \div a^n$ is omitted; it is stated that the decimal portion of the common logarithm of a number is independent of the position of the decimal point in any given sequence of digits, when the context makes it clear that this should have included the qualifying phrase "when the logarithm is expressed as *a positive decimal fraction* plus or minus an integer" (it is also stated that the common logarithm of any number may be expressed as *a positive decimal fraction* plus or minus an integer, obviously false for log 100); the review exercises at the end of algebra and trigonometry are insufficient in number, and omitted entirely for analytic geometry; on pages 205–6 the student might well raise the question as to how one tells from the notation $A \rightarrow 0$ whether the approach is made through positive or negative values of A (yet a careful distinction as to the result obtained has been made); in common with many texts, no mention is made of alternative definitions for the inverse trigonometric functions; there is at times some apparently unnecessary duplication of material, i.e., pages 37 and 320.

On the other hand, and in some cases of much more importance, there are some exceptionally good features: the careful discussion of the fact that the radical sign denoting square root calls for the positive square root of a positive number, with illustrations; a couple of excellent examples emphasizing the necessity for both parts of a proof by mathematical induction; the careful definition of a trigonometric identity, imposing the condition that only values of the unknown for which both members are defined are allowable; a definition of the ratio in the point of division formula in analytic geometry which avoids a common student error; an unusually complete discussion of the general equation of the second degree, particularly with respect to degenerate cases.

There is an unusually complete set of examples, with answers to the odd numbered examples; numerical tables include five place common logarithms, natural and logarithmic trigonometric functions; and a table of powers, roots and reciprocals. Anyone seeking a single text covering these three subjects cannot afford to omit this book from careful consideration.

CECIL B. READ

BIOLOGY AND HUMAN AFFAIRS, by John W. Ritchie. Cloth. Pages xiv+818. 14.5×22.5 cm. 1948. World Book Company, Yonkers-on-Hudson 5, New York. Price $3.40.

Those who are contemplating adoption of a new biology text should give this new edition serious consideration. The author has made "a flexible course" possible by offering nineteen somewhat independent units. His subject matter is more practical than academic and he admits that "more material has been included . . . than an average class can cover intensively in a year." He aimed to get away from a skeletal memory course and to provide more material for rapid learners. The non-technical vocabulary is said to be below tenth grade in difficulty.

The text is more abundantly and certainly more accurately illustrated than some of our current biology texts. The units are subdivided into a series of problems stated in question form. Each unit is followed by a useful summary, a unit comprehension test, and a series of suggested activities, applications and references. The unit of "Springtime Biology" is noticeable for its neglect of spring wildflowers whose hurried blooming activity is conspicuous to students. The last unit, "Our Biology Course," aims to bring the student to a more complete understanding of the wider values of biology.

The author is to be complemented on a well-organized, richly-illustrated, thoughtfully-written textbook.

JOSEPH P. MCMENAMIN

FIELDBOOK OF NATURAL HISTORY, by E. Laurence Palmer, *Professor of Nature and Science Education, Cornell University, and Director of Nature Education, Nature Magazine.* Cloth. Pages x+664. 15×23 cm. 1949. McGraw-Hill Book Company, 330 West 42nd Street, New York 18, N.Y. Price $5.00.

Fieldbook of Natural History appears after ten years of untiring effort on the part of its author. During the years of its preparation *Nature Magazine* published much of it as inserts.

Dr. Palmer's book is not intended for use by specialists. It was prepared for both young and old who possess a general interest in their natural environment, not only the plants and animals but also the stars, rocks, and minerals. Dr. Palmer recognizes the too often neglected fact that many people prefer a broad, though ever expanding, general knowledge to that which is narrow and specialized. Those who develop special interests can find other references to satisfy their needs.

Many scientists will criticize *Fieldbook of Natural History* for its technical inaccuracies, pointing to nomenclature which is ten years or more outdated, insects lacking antennal segments, or illustrations which are of little use for identification purposes.

Scientists who point to such errors here and there need not discredit the book on that basis. If they do, they fail to recognize that there are levels of accuracy and that they find mistakes only in their own specialty level—mistakes which are of concern to a minority and vital to no one. Nomenclature, for example, is an ever changing, dynamic science. A name used today becomes obsolete tomorrow. Only the specialist can keep pace—or needs to.

Fieldbook of Natural History is an extremely valuable contribution. It is a fine volume for anyone's nature library, whether he is student, teacher, or general reader. It is sure to stimulate interest and awareness to the natural environment and to provide almost unlimited information neatly condensed between two covers.

GEORGE S. FICHTER
Miami University
Oxford, Ohio

THE WORLD OF LIFE—A GENERAL BIOLOGY, by Wolfgang F. Pauli, *Bradford Junior College;* and edited by Bentley Glass, *Johns Hopkins University.* Cloth. Pages x+653. 34×17 cm. 524 figures. 1949. Houghton Mifflin Company, 2 Park Street, Boston 7, Massachusetts. Price $5.00.

Few textbooks are written at an appropriate level for general biology courses in colleges and universities. It is indeed gratifying to find one which not only is a comprehensive biology text but also is written in an attractive and stimulating style.

Dr. Pauli's *The World of Life* is such a book. Evolution, not only historical but modern trends and mechanisms, is the underlying theme of the entire book. The whole presentation is refreshing. Many texts are mere copies of old blueprints, but Dr. Pauli's approach is new and distinctive. Terminology has been carefully weighed so that it is neither too simple nor too difficult, and the author's pleasant style of writing keeps the text lively and interesting.

Part One describes the origin of our universe and the behavior and structure of matter. Part Two introduces life processes of metabolism and nutrition and the basic unit of all life, the cell. Part Three is a direct treatment of evolution: the principal theories and the evidences; a survey of the geological eras and periods, with descriptions and illustrations of dominant animals and an interesting analogy of the great passage of time to the number of lines and words in a twenty volume book; and the various mechanisms by which evolution occurs.

Part Four and Part Five review the plant and animal kingdoms, and in Part Six special attention is given the vertebrates. Emphasis is on evolutionary sequence in structure and behavior of both plant and animal organisms. Part Seven is devoted to heredity and genetics, with an entire chapter on the practical and theoretical applications of these principles in human genetics, eugenics, and euthenics. The book ends, appropriately, on the question of the future of the human species.

This book is highly recommended for use in college general biology courses, or as supplementary reading because of its original approach to biological evolution.

GEORGE S. FICHTER

BASIC COLLEGE PHYSICS, by Henry A. Perkins, Sc.D., *Professor of Physics, Emeritus, Trinity College.* Cloth. Pages ix+605. 1949. Prentice-Hall. Price $4.75.

The Preface to this text states eminently well the ambition of the author. Dr. Perkins covers the standard gamut of first-year college physics in a shorter somewhat simplified treatment of his unabridged *College Physics*. It is not as long nor as difficult as the original text, and the abridgement has not at all minimized *fundamental physics*. A number of topics have been eliminated but the same clarity in detailed explanation of basic principles prevails. Some sections have been revised. A few additions have been made on alternating currents and nuclear phenomena.

As in his earlier texts Dr. Perkins handles the subject in a scholarly fashion, in elegant English. His statements are meticulously made. The analytical portions are soundly done. The problems are adequate.

Considering the date of the text (1949) this reviewer hoped to find (1) the use of the rationalized MKS units, particularly in the sections on electricity and magnetism, since this system appears destined to supplant the cgs system; (2) some discussion of the origin of magnetic effects in terms of moving electric charges, since we are pretty well agreed that all so-called magnetic phenomena arise from forces between electric charges in motion. Nothing substantial is said of either.

Since a current is a flow of charge the expression "flow of current" is, as Sir J. J. Thomson said of a similar situation, "a meaningless conjunction of words." This, indeed, is the only serious literary lapse of the author in an otherwise elegant exposition.

Any student who masters the material in *this* text is eminently well-prepared to go on although the author's design is for those who are going no farther in the subject. It is an excellent text and an excellent reference book for beginners, and this reviewer often reads a section here and there to polish up a lecture.

JULIUS SUMNER MILLER
Dillard University
New Orleans 19, Louisiana

MODERN PHYSICS, by Charles E. Dull, *Late Head of Science Dept., West Side High School, Newark, N. J.;* H. Clark Metcalfe, *Science Dept., Brentwood High School, Pittsburgh, Pa.;* and William O. Brooks, *Science Dept., Technical High School, Springfield, Mass.* Revised Edition. Cloth. Pages x+601. Appendix x. 1949. Henry Holt & Co.

This book is a very good high-school physics text. The method of exposition is essentially Socratic and inductive, and the authors are substantially successful with it. The method is pedagogically excellent.

1. A topic is stated, usually in question form; e.g., what is a pendulum?
2. The discussion goes from the commonplace (in the pupil's experience) to the more technical.
3. Everyday applications are cited.

Both line drawings and photographs are abundant, and here the adage of a picture worth ten thousand words serves eminently well. Some little historical references are made. This is fine. In this reviewer's opinion much more of this should find its way into science books. It adds greatly to the human interest and beginners (as well as their elders!) should know more of the personalities under whose genius science and technology flowered.

There are chapter summaries and questions and problems, all more or less standard type. A glossary of new terms preambles each chapter, but definitions are dangerous things.

The format is pleasing and attractive, the pages being divided into two vertical columns. The leading questions appear in bold-face type.

The physics is essentially sound and no *glaring* technical errors were observed. The *exactness* of some statements may be questioned but at this level the wording is quite adequate. The appendices of formulas and tables are standard.

The book reads well and is sufficiently clear in the language to permit the teacher to do many of the things teachers should do: look at the questions, do problems, talk history and social implications. In other words, the text requires little explaining. So many science books need interpreters.

The book is deserving of success.

JULIUS SUMNER MILLER

PHYSICS IN THE MODERN WORLD, by Henry Semat, Ph.D., *Associate Professor of Physics, The City College, College of the City of New York.* Cloth. Pages xiii+434. 1949. Rinehart & Co. Price $5.00.

It is no strain on one's academic conscience to speak praisingly of this new book by Dr. Semat. This reviewer is thoroughly familiar with the author's earlier volumes, *Introduction to Atomic Physics* and *Fundamentals of Physics*, both of which are creditably done. This new text bears the same excellent scholarship and teachability.

This book is addressed specifically to students of the Arts and Social Sciences, and was written primarily for a course in Science for nonscience students. Although thus intended as a part of a larger scheme of instruction (with sections on Biology, Chemistry, Geology and Astronomy), it is thoroughly adequate as a terminal one-semester course in Physics for nonscience students.

The physics is elementary, as it needs to be, but good. The exposition reads well. The mathematics is a minimum, requiring only the rudiments of algebra and geometry. The questions and exercises (to which the answers are given) are thoroughly adequate for the purposes intended. The selection of material for such a clientele is a difficult task at best since the physicists would be in severe disagreement as to what should be embraced and the Arts and Social Science experts could not have an opinion!!

The sequence of topics is standard with excellent material on the structure of the atom and nuclear energy. The photographs are very good.

Historical material is used freely, and an abundance of portraits appears throughout the pages. This is a highly commendable aspect of the book, and as this reviewer has before stated, more of this should appear in science texts—even

those for the technical people. So many purely scientific souls are lacking in this very humanistic temper!

The appendix contains some good suggestions for Teachers and Students. Here again the problem is to stimulate *scientific* interest in people who have too long feared it! A short but good supplementary reading list is appended, together with the usual array of tables, and a glossary of some important terms.

The value of science to non-scientific people needs no discussion. The problem has always been how to get it to them without obscuring, with the purely technical, that which is good and essential for their understanding. Dr. Semat has done a good job with his assignment.

JULIUS SUMNER MILLER

PHYSICS—THE STORY OF ENERGY, by H. Emmett Brown, *Professor of Science, Head of the Science Department, New York State College for Teachers, Buffalo, N. Y.;* and Edward C. Schwachtgen, *Head of Department of Physical Science, Washburne Trade School, Chicago, and Instructor of Physics and Radio, Chicago Evening High Schools.* Cloth. Pages xi+593. 1949. D. C. Heath & Co. Price $3.20.

Of the making of books there is no end. But if the competition that this scheme of things produces makes for better books, this reviewer is all for it. Physics texts are getting better—at all levels. This one is eminently well done and is a credit to the authors, to the illustrator, to the publishers, and to physics as an art and as a science.

This high school text covers the usual gamut but is organized around the concept of energy. This, of course, is sound pedagogy and excellent science. The order of subject matter, that is, the sequence of topics, is unusual. Unit I: Sound Energy; Unit II: Light Energy; Unit III: Energy and the Work of the World; Unit IV: Electrical Energy; Unit V: Energy and Motion; Unit VI: Energy and Molecules. This departure from the classical, conventional order is refreshing—why do physics books *have* to begin with Mechanics? The treatment in this book is elegantly scientific and instructionally sound. This reviewer would like to teach it! The chapter contents are centered around several fundamental questions, called Problems, which are further reduced to smaller topics. Each chapter concludes with (1) Summary, (2) Things To Do, (3) Questions, (4) Problems, (5) Exercises For Advanced Study, (6) References. All of these are good. The references are excellently chosen and would constitute a very substantial and highly select library were a teacher to acquire them.

The format is highly attractive—two vertical columns make for easy reading—and the illustrations (528 of them!) by Theodore R. Miller, cannot be excelled. Many of the illustrations bear legends which are questions. These are delightful little devices for inciting the student to think! Experimental data are employed extensively in the formulation of laws, which is first-class science teaching.

This reviewer did not read the entire text but enough was read *critically* to formulate a scholarly opinion.

1. The physics is sound.
2. The organization is instructionally good.
3. The illustrations and captions are highly effective.
4. The book is among the best in its class.

JULIUS SUMNER MILLER

ALGEBRA, FIRST COURSE, by Raleigh Schorling, *Head of Department of Mathematics, The University High School and Professor of Education, University of Michigan;* Rolland R. Smith, *Coördinator of Mathematics, Public Schools, Springfield, Massachusetts; with the Coöperation of* John R. Clark, *Teachers College, Columbia University.* Cloth. Pages ix+406. 13.5×20.5 cm. 1949. World Book Company, Yonkers 5, N. Y. Price $1.92.

This is a new first year algebra textbook written by authors who have had rich

experience in textbook writing and teaching careers. It is based on the Second Report of the Commission on Post-War plans of the National Council of Teachers of Mathematics. In addition to the regular topics of first year algebra, the book includes good material on graphs and functional relationships, ratio and proportion, and numerical trigonometry. The chapter on quadratic equations is rather brief.

Each new topic is carefully developed in language and examples which the pupil can understand and follow. Explanations are usually re-inforced by simple applications which serves to emphasize the functional aspect of algebra. Enough practice material is given with each topic to assure mastery. A good balance is maintained throughout the book between written problems and practice exercises of algebraic processes. Cumulative and chapter reviews are given with each chapter. Provisions are made for maintaining skills in arithmetic by short groups of problems and tests in the fundamentals of arithmetic printed in the last chapter of the book.

This is a well written, up-to-date book which all high school algebra teachers will want to examine.

Doyle T. French
Elkhart High School
Elkhart, Ind.

Mathematics Review Exercises, by David P. Smith, Jr. and Leslie T. Fagan; *Masters in Mathematics, Laurenceville School, Lawrenceville, N. J.* Cloth. Pages vii+280. 24×16 cm. 1940. Ginn & Company. 2301 Prairie Ave., Chicago 16, Ill. Price $2.00.

This is a problem book, designed for review, or preparation for examinations. It will also be very valuable as a supplementary source of problem material. All topics covered in the College Entrance Examinations are included as well as several others which are growing in importance. For convenience the problems are organized by topics as follows: Arithmetic and Algebra, Plane Geometry, Correlated Exercises, Trigonometry, Advanced Algebra, Solid Geometry, Advanced Algebra and additional topics, Final Review, Summary.

Roughly there are 2100 problems with equations or expressions set down, 600 problems in which the student must translate words into equations, 350 proofs from statements and 55 constructions. There are 258 problems in examinations for the student's use in measuring his ability. The distribution of problems by area is as follows:

> Algebra and Arithmetic 1000, Geometry 450, Trigonometry 750, Advanced Algebra 374. Solid Geometry 364 with the areas not listed having between 25 and 75 each.

For the most part the problems are grouped in ascending difficulty and in a manner consistent with most texts now in use. Although the majority of the problems are of the type familiar to all mathematics teachers the authors have included some rather difficult and thought provoking combinations which were new to the reviewer. No attempt has been made to take into consideration approximate computation. However, a very valuable set of problems on the number systems with other bases is given. This would seem to be a valuable addition to the book. The approach is general with emphasis on understanding rather than answers. Many problems without numbers are given and some arithmetic problems call for proof. Radians and degrees are both represented. In the logarithmic and trigonometric problems many are to be solved without the use of tables. Theory of equations is covered from the relationship of coefficients and roots to Horners Method. Another feature is a list of sustained problems covering the entire field placed at intervals in the text. In the advanced topics we find expansion of a matrix of fourth order, proof by mathematical induction and a little analytic geometry.

The Final Review gives information on the College Entrance Examination and

designates problems for Beta and Gamma candidates. These lists are not tests but represent the types of problems found on the tests.

The final chapter summarizes important facts needed to solve the preceding problems.

This book does not teach, but is a very valuable aid to the teacher or student who needs more problems to solve for increasing his speed, accuracy and ability to analyze problem situations. It seems a few copies of this book would be beneficial in every mathematics class room.

PHILIP PEAK

YEAR'S FIFTH COMET VISIBLE THROUGH TELESCOPE

The year's fifth comet discovered in Russia will approach closest to the earth on Oct. 22, 1950, but it will not be a conspicuous sight that you can see in the sky.

Dr. Allan D. Maxwell, professor of astronomy of Howard University here, has computed an orbit based on observations from Russia and the U. S. Naval Observatory. Just now, the comet, visible only through a fair-sized telescope, is about 345,000,000 miles from the earth and 437,000,000 miles from the sun.

Next year, on its closest approach, it will be 90,000,000 miles from the earth and 182,000,000 miles from the sun. It is coming in toward the sun and the earth very slowly and traveling southward. It is probably traveling in a parabolic orbit.

The whole of its travel through the solar system is beyond the earth's orbit and it is tilted 34 degrees to the plane of the earth's travel.

$25,000 PRIZE ANNOUNCED FOR NEW KNOWLEDGE OF SUGAR

One of the largest prizes of the scientific world, $25,000, will be awarded again next year in recognition of new knowledge about sugar or other carbohydrates. Dr. Harlow Shapely, chairman of the National Science Fund of the National Academy of Sciences has announced.

The 1950 grand prize of the Sugar Research Foundation Inc., will be open for entries until Feb. 1. Scientific studies of sugar in living processes, as a food and as industrial raw material are being stimulated by the award. Four previous prizes annually have been given.

NEW CAST IRON NOT BRITTLE BUT CAN BE BENT OR TWISTED

Now protected by patents just issued, details of a new cast iron that can be bent or twisted were presented to the Gray Iron Founders' Society by Don Reese, International Nickel, Bayonne, N. J. Because it is not brittle like ordinary cast iron, the new product will have many applications.

This new ductile cast iron combines processing advantages of cast iron, such as fluidity, castability and machinability, with many of the product advantages of steel, he stated. The essential feature of the invention is the introduction into and retention by the molten iron under treatment of a small but effective amount of magnesium.

The presence of the magnesium produces a new graphite structure which is in the form of spheroids or compacted particles. Due to the elimination of a substantial amount of the usual weakening flake graphite, the new product possesses high tensile strength, elasticity, toughness and ductility.